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DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 33

STORAGE OF WATER ON GILA RIVER, ARIZONA.—LIPPINCOTT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

STORAGE OF WATER

ON

GILA RIVER, ARIZONA

BY

JOSEPH BARLOW LIPPINCOTT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, December 1, 1899.

SIR: I have the honor to transmit herewith a manuscript prepared by Mr. J. B. Lippincott, giving the results of surveys of reservoirs on Gila River, Arizona, and to recommend that it be printed in the series of Water-Supply and Irrigation Papers.

The investigations upon which this report is based were originally intrusted to Mr. Arthur P. Davis, as he was familiar with the conditions through a preliminary survey. Before the field work was completed, however, his services were required by the Nicaragua Canal Commission, to extend the studies of the water supply of Central America. The responsible oversight was then intrusted to Mr. J. B. Lippincott, who up to that time had been assisting Mr. Davis.

This report has been written by Mr. Lippincott, and his conclusions have been verified by Mr. James D. Schuyler. The latter has prepared a concise discussion of the matter, but at this time it is necessary only to quote his general conclusions and recommendations, as follows:

(1) That a minimum of 40,000 acre-feet of water annually should be stored for the supply of the Indian reservation.

(2) That it is not feasible to obtain this supply from Queen Creek, although the construction of the dam and reservoir proposed on the stream is feasible if a sufficient water supply were available.

(3) That the Gila River is the only available source of permanent supply.

(4) That it is not feasible or advisable to build a dam and reservoir on the Gila for storing so small a quantity as 40,000 acre-feet, on account of the rapidity with which a small reservoir must be filled with silt.

(5) That it is not feasible to construct a reservoir outside of the immediate channel of the Gila River of sufficient capacity to provide for the wants of the Indians, filling the same annually by a conduit from the river.

(6) That it is not advisable to build a dam and reservoir on the channel of the river of less capacity than one-half the total annual flow of the river in minimum years.

(7) That feasible reservoir and dam sites exist on the Gila at the Buttes, Riverside, and San Carlos.

(8) That it is not feasible to build a masonry dam at the Buttes, on account of the rotten quality of the rock, the great depth to bed rock, and the excessive height of dam required to obtain a storage of 174,000 acre-feet, or about one-half the minimum flow of the stream.

(9) That the construction of a combination rock-fill and masonry dam is feasible at the Buttes at a cost of $2,643,327, storing 174,040 acre-feet, but that it is not feasible to construct a dam of any type of greater height or capacity.

(10) That the Buttes reservoir of the stated capacity may be expected to fill with solid matter in eighteen years, unless dredged or sluiced out.

(11) That it is feasible to construct a masonry dam at Riverside at a cost of $1,989,605, including damages for right of way and diversion dam at the head of the Florence canal, forming a reservoir with a capacity of 221,134 acre-feet.

(12) That it is feasible to increase the height of dam at the Riverside dam at least 70 feet higher than the one estimated upon, giving an ultimate reservoir capacity of about 650,000 acre-feet, which would not be filled with solid matter short of sixty-seven years.

(13) That it is feasible to construct a masonry dam at San Carlos at a cost of $1,038,926, including damages for right of way and diversion dam at the head of the Florence canal, forming a reservoir of 241,396 acre-feet capacity, and that the water supply is ample to fill such a reservoir in the years of minimum flow, and that the volume of storage will irrigate at least 100,000 acres in addition to the irrigation of the lands of the Indians.

(14) That it is feasible to construct a dam at San Carlos at least 70 feet higher than that contemplated in the estimates, forming a reservoir whose ultimate capacity would be approximately 550,000 acre-feet and whose probable life of usefulness would be sixty-three years before being filled with silt.

(15) That provision should be made in the working plans for these ultimate extensions suggested and the right of way reserved in the reservoir basin for the additional area that may ultimately be flooded.

(16) That the San Carlos dam should be built as the first step to be taken for the storage of water upon the Gila and that all other available sites should be permanently withdrawn from entry with a view to their ultimate utilization for storage purposes.

(17) That the working plans for the San Carlos dam should be drawn to permit of the complete utilization of all power which may be developed from the head of the water issuing from the reservoir and steps be taken for realizing upon the full commercial value of the power.

(18) That that portion of the public domain which can be irrigated and reclaimed from the surplus storage of the Gila River reservoirs, over and above what is required for the Sacaton Indian Reservation, should be withdrawn from entry, segregated into an irrigation district, provided with a system of canals of distribution, and only offered for sale at a rate commensurate with their true value as irrigable lands with water rights, the proceeds to be placed in a fund to be used only for continuing the improvement, extension, and care of reservoirs and storage dams on the Gila River.

In addition to the investigation authorized by the act of July 1, 1898, related work was carried on at the same time under the annual appropriation for measuring the streams and determining the water supply, thus furnishing general information which has been embodied in the following pages. No attempt has been made in this paper to discriminate between the data acquired by the two classes of field work.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

DRIVING PIPE IN BED OF GILA RIVER AT THE BUTTES, ARIZONA, FOR DIAMOND CORE DRILL

STORAGE OF WATER ON GILA RIVER, ARIZONA.

By JOSEPH BARLOW LIPPINCOTT.

EXISTING CONDITIONS.

LOCATION OF RESERVATION.

The Gila River Indian Reservation consists of a tract of 357,120 acres lying on both sides of Gila River, in southern Arizona. It extends from a point about 9 miles west of Florence to the mouth of Salt River, the principal tributary of the Gila, and is approximately 12 miles south of Phenix, the capital of the Territory. The greater portion of this reservation consists of land whose gentle slopes are well adapted to irrigation. From June 1 to October 1 the weather is exceedingly warm. The relative humidity of the locality, however, is low, so that the effect of the heat is largely mitigated, and prostrations from this cause are rare. It is probably as well suited to occupation from a climatic standpoint as the great valleys of central California or the southern Atlantic coast. The winter season is delightful, the temperature seldom falling lower than 20° F.

The lands of this reservation are arid, the annual rainfall being between 7 and 9 inches, a large portion of the precipitation occurring during the winter or nongrowing months. The growth of all crops in this district is wholly dependent upon irrigation, but with water they can be raised in continuous rotation, while successful dry farming is an impossibility. What is true of the Indian reservation also applies to the adjacent lands of the Gila River Valley. Wheat, barley, corn, and alfalfa grow luxuriantly when watered. The deciduous fruits flourish, but winter temperatures are too low for the citrus species.

DESCRIPTION OF TRIBES.

The Gila River Indian Reservation is occupied chiefly by the Pima and Maricopa Indians and a limited number of Papagos. The first knowledge we have of these Indians is obtained from a narrative of Cabeza de Vaca, a Spanish explorer, who visited this region about the year 1535, after an adventurous journey overland from Florida. This traveler describes them very much as they are to-day. They occupied the same lands as at present, and have evidently long been industrious and successful farmers and irrigators, as they continued to be for many years after the acquisition of Arizona by the United States. Their average wheat crop was about 2,000,000 pounds a year, besides

which corn, pumpkins, beans, sorghum, and vegetables were raised in large quantities. They manufactured ollas, or earthen jars, and baskets and wove very fine blankets and cotton fabrics. They lived in small villages and held their lands in severalty.

The Pimas have always been friends of the whites and enemies of the Apaches. They gave succor and assistance to the early white settlers, and their doors were always open to peaceable whites or Indians when hard pressed by the savage foe. It is their boast that their hands were never stained by the white man's blood. It was under such conditions that they were joined, about a century ago, by the Maricopas, who came as fugitives from the more powerful Yuma tribe. When the belligerent Apaches gave trouble to the settlers, the United States troops sometimes obtained substantial aid and comfort from the Pimas in the way of subsistence.

The agriculture of the Pima Indians was carried on entirely by irrigation with water diverted from Gila River. These tribes have always supported themselves, and their progress toward civilization has been regarded as one of the encouraging features of the Indian problem. During the last ten years, their irrigating water having been taken away from them, they have lapsed into indolence, want, and vice.

DECREASE OF WATER SUPPLY.

Their condition of prosperity, industry, and independence continued until, by the settlement of the Gila Valley above the reservation, the water supply was partly cut off and began to be deficient for the cultivated lands on the reservation. No very serious shortage occurred, however, until after the construction of the Florence canal and its diversion dam, heading about 15 miles above the eastern limit of the reservation on Gila River. When this canal was projected, early in the year 1886, Agent Wheeler called the attention of the Department of the Interior to the fact that if the construction of this canal were permitted, it "would practically destroy the farms of the Pima and Maricopa Indians living on the river," and that the effect would be to render the Indians helpless and destitute, the water being absolutely necessary to their existence. On March 2, 1886, the subject was referred by the Department to the Attorney-General, who directed the United States district attorney for Arizona to take the necessary steps to protect the Indians from the effects of the projected canal. The matter was delayed until July of the same year, when the Director of the Geological Survey was instructed by the Secretary of the Interior to investigate and report to the Department the effect which the proposed canal would be likely to have upon the water supply for the Indian reservation. As a result of the investigation the following facts were established:

(1) That the water supply of the Pima and Maricopa reservations under present conditions is no more than sufficient for the wants of the Indians.

(2) That the construction of a dam by the Florence Canal Company of the character represented in the correspondence will give the control substantially of all the water of the Gila River; and if the owners of the dam carry the water right also, they can deliver the water to the reservation or not, as best suits their plans.

(3) That the lands outside the reservation which could be economically supplied with water by such a canal greatly exceed in area the amount that the river is capable of supplying, and that the company, with the water rights established, would own the water, with a demand far exceeding the supply, and the Government would have to approach them as a competitor in the market to obtain a supply for the Indians of the reservation.

(4) That if the water supply from the river be shut off, the Indian reservation would become uninhabitable.

(5) If the dam and canal should be constructed, the present and immediate prospective needs of the reservation might be supplied therefrom, and there would be some surplus water to be used for irrigating lands outside the reservation.

(6) That if the agriculture of the Indians residing on the reservation is to have normal growth, and it be the intention to settle other Indians of the neighborhood who are not supplied with agricultural lands on the reservation, the greater part, and perhaps the whole, of the waters of the Gila will be necessary therefor.

As a result of this report the Department of Justice was again requested to take such steps as would be necessary to prevent the diversion of waters of Gila River to the injury of the Indians of the Pima and Maricopa reservations. Some offers of compromise were made by the canal company, and legal steps were held in abeyance until the canal was constructed, and no successful attempt was ever made to prevent the diversion of the river by the Florence canal or to compel such diverters to supply the Indians with water for irrigation, and the matter was finally allowed to drop by the Department of Justice. The result of the diversion was to deprive the Indians of the greater portion of their water supply during the period when the water was most needed to mature their crops. The shortage has been greater some years than others, depending to a certain extent upon the season, whether abnormally dry or otherwise, but in general there has been a progressive decrease of the water supply for the reservation, due originally, in great measure, to the diversion by the Florence canal.

Recent events have, however, altered the aspect of the question, from the fact that the supply for the Florence canal itself is now short, owing to the diversion for irrigation far above that point, chiefly in Graham and Cochise counties, Arizona. The solution of the problem has become more difficult by reason of its postponement and the condition of the Indians more deplorable. Year after year they plowed and sowed and irrigated their crops, only to have them destroyed by drought before maturity by lack of sufficient irrigation water in the drier months. Naturally they have become discouraged by these fruitless efforts, and great demoralization has resulted. A few who are favorably located at points where water appears in the dry bed of the Gila can still mature their crops; a few others are able to eke out an existence by hauling wood or other precarious employments, while

the larger number have become more or less dependent upon charity or have degenerated into thieves and vagabonds.

NECESSITY FOR RELIEF.

On March 27, 1895, Mr. J. Roe Young, United States Indian agent at Sacaton, made a terse statement of the case to the Indian Bureau, closing his letter with the following recommendation:

What is best to be done I do not know. I recommend, however, that a competent, thorough, and skillful engineer, well acquainted with irrigation questions, be employed to ascertain and report, first, whether or not under existing conditions a supply of water adequate to the needs of these Indians can be obtained and retained permanently, and then, if such a supply can be obtained, what is the best, most feasible, practicable, and economical method of doing so. To properly do this the engineer should examine carefully the past and present condition and flow of the Gila River, the amount of water which formerly passed through this reservation, and the amount we are now receiving; the number and amount of inches of water for which charters for ditches have been granted in the different counties through which the Gila flows, and the amount of water taken out under these charters, together with the number of such charters now legally in force; the underground currents and rock strata along the river, and all matters which, taken together, may lead to some solution of this question. I have been unable to get an estimate of what amount such an investigation and report will cost, but I would suggest that the sum of $5,000 be set apart from any appropriation available for this purpose. Competent and first-class engineers, with ability to make such a report as this case requires, are scarce and high-priced, and they have to be well paid. It would be money thrown away to employ a man not thoroughly posted.

This matter should be taken up soon, in order that we may know what to expect for next year.

Mr. Elwood Hadley, who is now (1899) the Indian agent at Sacaton, in describing the present condition of the Indians of the Gila River Reservation, writes as follows, under date of September 25, 1899:

Approximately 6,000 Indians—Pimas, Papagos, and Maricopas—are dependent for their subsistence upon the lands of the Gila River Reservation, which reservation contains 357,120 acres. It is estimated that half of the land could be made productive with water to irrigate it. The water supply in the Gila River the present season, owing to its use for lands above us, has not been sufficient to irrigate 1,000 acres. Fully half the crops planted have not produced enough for seed. This land is very fertile. The condition of affairs here shows that in the past three years there has been a large falling off in the water supply for irrigation. The reason is apparent in the absorption of the water by additional cultivated lands above.

I notice in the Indians a restlessness as they realize their helpless condition, and and am often confronted with the solicitous queries, What are we to do? If we plant what we have, what assurance have we of getting it back? Under favorable conditions these Indians, being agricultural and pastoral, would soon become independent, prosperous, civilized citizens. Otherwise, discouragement, hunger, and destitution are their lot. A nomadic life being taken on, their old tribal nature asserts itself, and the expenditures hitherto made and being made by the Government for their education and improvement prove a curse to them rather than a blessing.

It is now necessary to issue considerable subsistence to the Indians whose crops

have been a failure, and this aid will have to be largely increased under the existing limited water supply. A supply of water would permit of the Pima boarding school establishing a model farm, greatly reducing the cost of maintaining the school of 200 pupils, and be a most valuable educational factor in the school life of the pupils. The available Indian labor in the construction of the reservoir is an important factor, as it is much better to provide them labor with pay than keep them as paupers. These Indians are willing to work, and their moral status is good. Their attitude toward the United States has always been friendly. They have saved the Government in protecting the early settlers from the ravages of the Apaches. They have kept themselves within the bounds of law and order, and they are now left upon the desert without water. Humanity speaks, economical administration for the sustenance of the Indians speaks, and Nature, in her wise provisions, says, "Let man's means and intelligence be made operative, that these Indians, whose claims are meritorious, be reinstated in self-sustenance and lifted to the plane of prosperous American citizens."

INVESTIGATION IN 1896.

In November, 1895, the Secretary of the Interior instructed the Director of the Geological Survey to detail a civil engineer to make the examination recommended, and Mr. Arthur P. Davis, hydrographer, was accordingly assigned to this task, in which he was assisted by Mr. Cyrus C. Babb, assistant hydrographer, and Mr. J. B. Lippincott, resident hydrographer for California. Six months of time and $3,500 were expended in the field on the preliminary investigation, and a report was submitted in 1896,[1] entitled The Report on Irrigation Investigation for the Benefit of the Pima and Other Indians on the Gila River Indian Reservation, Arizona.

It was proposed to construct a dam of masonry to the height of 170 feet above the bed of the river, at which height natural facilities occur for the discharge of surplus waters through adequate spillways. This would afford a storage of about 200,000 acre-feet of water below the flow line of 160 feet above the bed of the river. The provisional estimate of the cost of this project aggregated $2,244,000. The great uncertainty attaching to this project was the location of bed rock at a great but unknown depth. Numerous reports were obtained of soundings varying from 40 to 50 feet in depth without striking bed rock.

Inquiry showed that it would be impossible to obtain suitable drilling machinery for a thorough exploration of the foundation, and as a preliminary makeshift the method of sounding by driving rods was resorted to. Rods were driven in eleven places, at intervals of 40 feet, in the proposed dam site, eight of the soundings being 50 feet or more and one reaching the depth of 65 feet. It was impossible with the means at hand to determine whether or not the rods had reached bed rock, but the preliminary estimates were made on the hypothesis that the depth of rock was 65 feet, and in the report of the work it was recommended that "thorough exploration should be made with a core drill before beginning of construction of the dam."

[1] Senate Doc. No. 27, Fifty-fourth Congress, second session.

INVESTIGATION IN 1899.

For the purpose of continuing the investigation along the lines recommended by Mr. Davis a paragraph was inserted in the act making appropriation for current and contingent expenses in the Indian Department, approved July 1, 1898, as follows:

For ascertaining the depth of the bed rock at a place on Gila River, in Gila County, Arizona, known as the Buttes, and particularly described in the Senate Document Number Twenty-seven, Fifty-fourth Congress, second session, and for ascertaining the feasibility and estimating in detail the cost of the construction of a dam across the river at that point for the purpose of irrigating the Sacaton Reservation, and for ascertaining the average daily flow of water in the river at that point, twenty thousand dollars, or so much thereof as may be necessary, the same to be expended by the Director of the United States Geological Survey, under the direction of the Secretary of the Interior: *Provided*, That nothing herein shall be construed as in any way committing the United States to the construction of said dam; and said Director shall also ascertain and report the feasibility and cost of the Queen Creek project mentioned in said Senate document.

In order to carry out the provisions of this act stream measurements were begun on Gila River at the Buttes and on Queen Creek at the site of the proposed dam, in November, 1898, and have been maintained to date (October, 1899). As the site at the Buttes was inaccessible by heavy wagons, a road was built to facilitate the transportation of machinery to the site for drilling. Bids were invited by advertisement for the exploration of bed rock, but were rejected, as it was found that the amount of drilling desirable would, under the most favorable proposal, cost more than the available funds. Two diamond drills, a few diamonds, and two pipe-driving machines were loaned to the Survey for this work by the Nicaragua Canal Commission, and borings were begun at the Buttes in January, 1899.

Twenty-five holes were put down to bed rock at the Buttes with a diamond core drilling apparatus. These holes were distributed up and down the narrow portions of the canyon in order to determine the most acceptable point for the location of the dam. The depths reached were unexpectedly great. This work is described in detail under the account of the diamond core drill borings on page 48. The maximum depth reached by any of the holes was 122.6 feet to bed rock. Because of this great depth an effort was made to find another location for a dam that could utilize the Buttes reservoir site as filed upon under the United States laws. The appearances were favorable for the proximity of bed rock to the surface near the head of the Florence canal, 3½ miles below the Buttes, where the canyon is quite wide, but where outcroppings of rock in places occur. The depth to bed rock at this site—82 feet 2 inches—as determined by borings shown on the map, Pl. VIII, *B*, was too great to justify the location of the dam at this place. The portion of the canyon was contoured between the old reservoir survey, which began at the Buttes dam site proper and the head of the Florence canal, so that a revised capacity of the reservoir could be computed if the dam

should be built at the head of the Florence canal. At a point 4 miles above the Buttes, where a dike of volcanic rock apparently of more recent geological formation than the surrounding country crossed the canyon, another exploration for bed rock was made. The canyon at this point at the base of the cliffs is 459 feet in width. As a hole was put down to a depth of 96.3 feet without finding bed rock at this point, this location was condemned as a dam site without further exploration, particularly in view of the excessive length of dam required.

In order to determine the feasibility of constructing a dam at the Buttes, as compared with other possible locations, the Gila River above this location was explored for reservoir sites, and three were found of ample storage capacity. At Riverside, 12 miles above the Buttes, by the course of the river, an available locality was selected and fourteen holes were sunk, which determined a granite bed rock of good quality to exist at a maximum depth of 75.5 feet. At the San Carlos dam site, the next location above, three holes were put down to determine the depth of bed rock. This was the last dam and reservoir site discovered. The high water then interferred with the work to such an extent that it had to be abandoned in August. The data obtained from these three holes are very meager and should be extended, but they had to be accepted in this estimate as determining bed rock at that point. At the Guthrie reservoir site, which is above Solomonville and uppermost of three available locations examined, a detailed survey was also made. The rock at this dam site consists of a mixed volcanic product, there being strata of gravel deposited between various lava flows. This was considered sufficient in itself to condemn this site for construction purposes. A railroad passes through the length of the reservoir and through the dam site, and a change in its location would be a matter of difficulty and large expense.

The upper portion of Gila River and its principal tributaries were explored by Mr. Cyrus C. Babb, hydrographer, as well as the basin of San Pedro River. In both the Gila and San Pedro basins measurements of all canals were made in order to determine the amount of water returning to the river from irrigation and for purposes of general information. This return water has a particular bearing upon our project as contemplated in that the irrigation of 120,000 acres of land in the neighborhood of Florence and Sacaton may be expected to increase the flow of the lower portion of Gila River in a way similar to that of the cases investigated where irrigation has been practiced for a term of years. In other words, if 50 per cent of the water used for irrigation around Solomonville, on the upper portion of the river, returns to the river below the places where it is used for irrigation, and it may again be used for like purpose below, a similar action may be expected below the irrigated lands which are supplied from this proposed reservoir system. Measurements of return water, or "seepage measurements," were also made in the vicinity of Phenix, which show similar conditions.

The canyon of the Gila, between the mouth of the San Pedro and the San Carlos dam site, was explored and found to be 31 miles in length. It is a narrow gorge, as shown on Pl. II, being thus an excellent conduit for the passing of the liberated water from the San Carlos dam site to the irrigable lands below. A traverse survey was made throughout its length. Observations for determining the average evaporation, the range of temperature, and the volumes of suspended silt in the river have been maintained at the Buttes during the period of the survey. A canal line has been surveyed from the Buttes dam site past the head of the Florence canal, a distance of 4 miles. This canal would be used in connection with the Buttes reservoir site for the purpose of delivering its water to the irrigable lands, and largely for the development of power, which could be used, if desired, in the settlements that would spring up under this system.

Owing to the questionable character of the rock for building at the Buttes dam site, quarry tests were made, as described fully under the description of the Buttes dam. Mr. E. Duryee, chemist and cement expert, of Colton, California, investigated thoroughly the rocks of all the localities in question, in order to determine the feasibility of the manufacture of a natural hydraulic or a Portland cement. His investigation, as shown in detail on later pages, also determined the possibility of using the siliceous rocks of the respective localities for blending with Portland cement in the manufacture of what is known as "sand cement." The extent of public domain in the irrigable districts was determined from the land-office records at Tucson, Arizona.

Mr. J. H. Quinton was engaged to assist in the designing of the dams and other engineering works. He visited all the localities in question and made a careful field examination. Mr. James D. Schuyler was employed for purposes of consultation in the planning of the work, in an advisory capacity, and for this purpose made detailed examinations of the various dam sites on two occasions during the progress of the field investigation. The service which Mr. Schuyler has rendered in this capacity has been of prime importance to the work, owing to his very extended experience in the construction of dams for irrigation purposes.

The general plans for dams at all points have been matters of discussion during a period of months by all the engineers connected with this investigation. Each has contributed his share toward the formation of the final plans which Mr. Quinton has prepared. The office work for the report has been done in Los Angeles, where the plans and estimates have been prepared. Numerous laboratory tests of material from the dams and of the sand cements have been made. Mr. Arthur P. Davis, hydrographer, was in charge of the organization of the field work and of its execution until May 1, 1899, when he was detailed to assist the Nicaragua Canal Commission in its work on the Isthmus. Mr. Davis practically outlined the field work. His ideas with reference to plans of construction have been given most careful

HYDE FORBES
GEOLOGIST & HYDROGRAPHIC ENGINEER

A GILA RIVER CANYON, 15 MILES BELOW SAN CARLOS DAM SITE.

B. GILA RIVER CANYON, 8 MILES BELOW SAN CARLOS DAM SITE.

consideration in reaching final conclusions, and to him is due the credit, in large part, for the successful carrying out of the work and for its breadth and scope.

AMOUNT OF WATER REQUIRED.

In order to determine the amount of water that will be required for the Indians on the Gila River Indian Reservation, Mr. Elwood Hadley, United States Indian agent at Sacaton, was requested to make a statement on the subject. In his reply, dated October 12, 1899, he writes:

> It is estimated that there are nearly 4,500 Pima and Maricopa Indians on the reservation dependent for their subsistence upon its lands. South of this reservation, in the country lying between the Southern Pacific Railroad and the border line of Mexico, it is estimated that there are nearly 2,000 nomadic Papagos, who derive much of their subsistence from the Pimas of this reservation (Gila River) in exchange for their labor. The Pimas are liberal and kind to their more unfortunate brothers, and give them a share of their products in return for their labor in harvesting the crops.
>
> The estimated number of Indians under my care is as follows: Pimas, 4,200; Maricopas, 350; Papagos, 2,700; total, 7,250.
>
> The number named above who live on reservations away from here would gladly come here if they could be furnished with water. It is estimated that 2 acres of land will sustain an Indian.

The report of the Commissioner of Indian Affairs for 1896 gives for the Pima Agency the following population: Pimas, 4,260; Maricopas, 340; Papagos, 1,224; Papagos, nomadic, 2,046—total, 7,870. This does not state, however, whether these are actually on this particular reservation or on others.

In the report of Mr. Arthur P. Davis, of 1896, it is estimated that 1.5 acres of ground is necessary for the support of each Indian. This estimate is thought to be liberal. In the irrigated districts of southern California an inhabitant to each acre is sustained. For the irrigation of grain probably 1.5 acre-feet of water is sufficient for the complete development of the crop for each season; but for the growth of alfalfa or orchards a lower duty of water will be required, and 2 acre-feet per acre is assumed in this report to be a satisfactory supply. If there are 7,250 Indians now located upon this reservation or deriving their subsistence from it, each requiring 1.5 acres of irrigated land, it would be necessary to supply 10,875 acres with water to meet present demands. At the rate of 2 acre-feet of water for each acre irrigated, it will be necessary to furnish 21,750 acre-feet to the reservation to meet this requirement. There will doubtless be other Indians on neighboring reservations on the lower portion of Gila River, whom the Department would desire to move onto the Gila Reservation in case an abundant supply of water could be furnished to them. In view of these possible transfers, and of the natural increase in numbers of the tribes now dependent upon the reservation, a prospective demand on the reservoir system of 40,000 acre-feet is considered necessary.

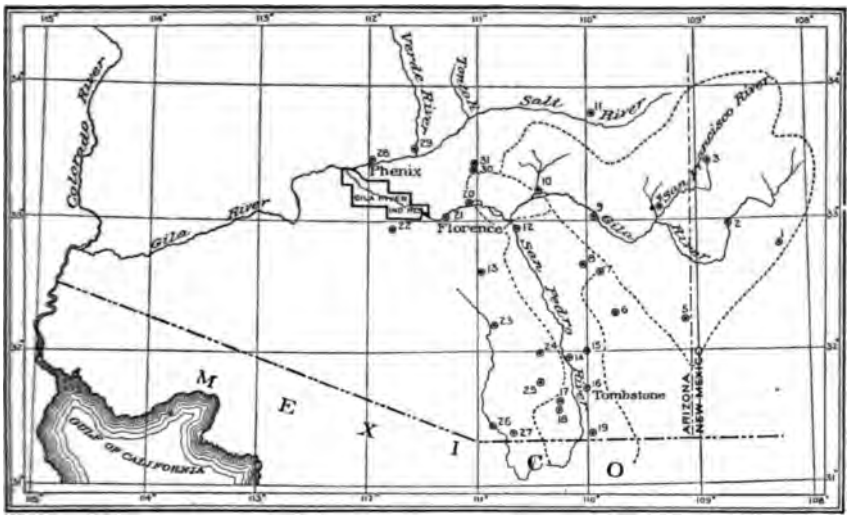
WATER SUPPLY.

PRECIPITATION.

Rainfall observations have been taken at thirty-one different points in the basin of Gila River above the Buttes, as shown on Pl. III, *A*, the earliest record beginning at Fort Bayard, New Mexico, in 1867. Undoubtedly the greatest precipitation of the basin occurs in the higher mountains, in its northeastern portion. The records for these mountain districts are rare, most of them being taken in the valleys where settlements and agriculture occur. It is probable, therefore, that the actual rainfall for the basin is greater than that indicated by the tables and diagrams. For the purpose of this report the rainfall observations in the basin of Gila River above the Buttes have been grouped in three classes in the following table—first, the Gila Basin proper, exclusive of the basin of the San Pedro; second, the basin of the San Pedro; and third, a series of observations at three stations in the vicinity of Florence, five stations in the basin of Santa Cruz River, which stream enters the Gila below the mouth of the Salt, and three sets of observations in the vicinity of Phenix. The segregation of the records into the groups named is for the purpose of comparing the relative amount of water available for storage purposes at the reservoir site at San Carlos and at the Buttes.

Annual rainfall, in inches, in basin of Gila River above San Carlos, Arizona.

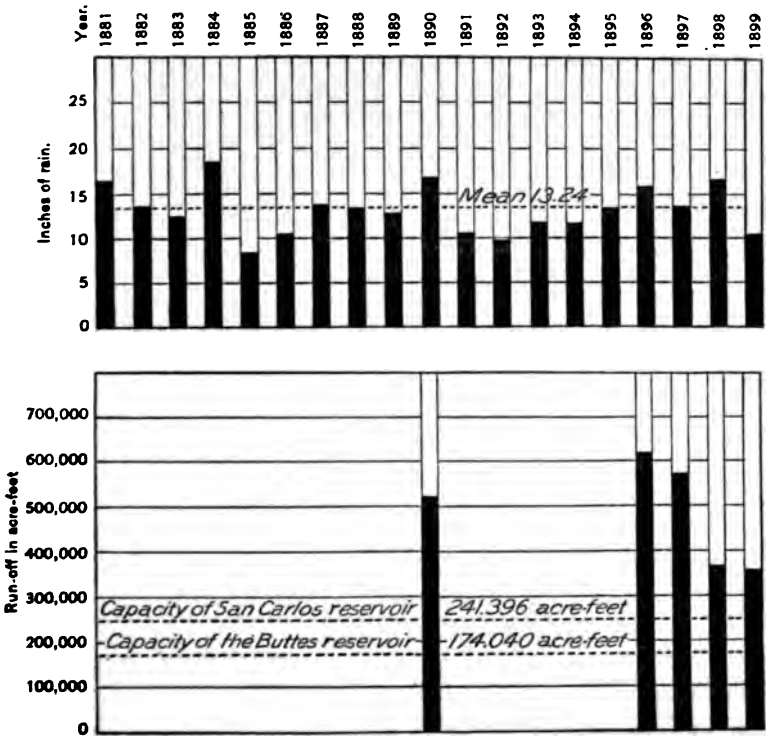
	Fort Bayard.	Gila.	Alma.	Oro.	San Simon.	Willcox.	Fort Grant.	Cedar Springs.	Fort Thomas.	San Carlos.	Fort Apache.	Mean above San Carlos.
Elevation (feet)	6,022	.....	5,500	3,610	3,611	4,164	4,860	4,900	2,700	2,450	5,050	.....
Year:												
1867	13.87	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1868	15.23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1869	12.84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1870	10.07	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1871	5.79	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1872	13.61	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1873	22.18	.....	.....	.....	.....	.....	17.99	.....	.....	.....	.....	.....
1874	20.38	.....	.....	.....	.....	.....	17.81	.....	.....	.....	.....	.....
1875	19.66	.....	.....	.....	.....	.....	20.91	.....	.....	.....	.....	.....
1876	18.94	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.74	.....
1877	13.12	.....	.....	.....	.....	.....	10.13	.....	.....	.....	12.50	.....
1878	.....	.....	.....	.....	.....	.....	16.46	.....	.....	.....	28.61	.....
1879	.....	.....	.....	.....	.....	.....	12.82	.....	.....	.....	18.58	.....
1880	.....	.....	.....	.....	.....	.....	15.74	.....	.....	.....	14.77	.....
1881	.....	.....	.....	.....	.....	12.11	18.96	.....	11.41	.....	31.12	18.40
1882	.....	.....	.....	.....	6.50	8.58	15.42	.....	8.66	15.27	27.62	13.69
1883	.....	.....	.....	.....	7.15	8.73	15.48	.....	10.85	12.21	21.65	12.68
1884	.....	.....	.....	.....	10.37	14.38	25.67	.....	18.16	20.41	29.47	19.74
1885	.....	.....	.....	.....	2.39	8.51	9.21	.....	8.70	8.19	15.58	8.76
1886	.....	.....	.....	.....	2.02	9.37	.....	.....	10.86	10.44	21.06	10.75
1887	13.59	.....	.....	.....	.99	16.49	24.32	.....	16.35	8.68	17.84	14.04
1888	13.42	.....	.....	.....	4.55	11.93	14.20	.....	13.34	13.04	18.89	12.77
1889	7.21	.....	.....	.....	.....	13.68	13.32	16.44	10.89	13.40	17.10	12.60
1890	.....	.....	.....	15.94	8.43	.....	15.88	.....	13.93	17.86	26.72	16.46
1891	10.30	.....	.....	10.90	4.04	7.36	12.21	.....	.....	11.00	13.36	9.86
1892	8.80	.....	.....	.....	2.57	8.01	7.90	.....	.....	12.05	12.70	8.67
1893	.....	.....	.....	.....	5.65	3.95	13.85	.....	.....	12.53	15.08	10.21
1894	8.67	.....	.....	.....	3.24	5.88	13.53	.....	.....	10.15	17.42	9.81
1895	14.45	12.41	16.51	.....	2.78	8.04	13.22	.....	.....	14.41	18.03	12.48
1896	19.98	17.87	15.09	12.99	4.36	9.22	15.99	.....	.....	13.88	16.09	13.84
1897	17.00	14.44	15.68	10.69	.....	5.66	13.87	.....	.....	7.90	14.93	12.52
1898	16.21	15.22	17.26	16.14	.....	8.16	14.26	.....	.....	7.79	20.55	14.45
1899	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mean	14.06	14.98	16.13	13.33	4.65	9.42	15.34	.....	12.32	12.31	19.54	12.87



A. LOCATION OF RAINFALL STATIONS IN BASIN OF GILA RIVER.

Rainfall stations:

1. Fort Bayard.
2. Gila.
3. Alma.
4. Oro (Clifton).
5. San Simon.
6. Willcox.
7. Fort Grant.
8. Cedar Springs.
9. Fort Thomas.
10. San Carlos.
11. Fort Apache.
12. Dudleyville.
13. Oracle.
14. Benson.
15. Dragoon.
16. Tombstone.
17. Fort Huachuca.
18. Huachuca Mountains.
19. Bisbee.
20. Buttes.
21. Florence.
22. Casa Grande.
23. Tucson.
24. Pantano.
25. St. Helena Ranch.
26. Calabasas.
27. Lochiel.
28. Phenix.
29. Fort McDowell.
30. Pinal Ranch.
31. Silver King.



B. RAINFALL AND RUN-OFF IN GILA BASIN.

Annual rainfall, in inches, at stations in basin of San Pedro River, Arizona.

	Dudleyville.	Oracle.	Benson.	Dragoon.	Tombstone.	Fort Huachuca.	Huachuca Mountains.	Bisbee.	Mean San Pedro Basin.	Mean above the Buttes.
Elevation (feet)	2,360	4,500	3,580	5,436	.....	5,100	5,000	5,500	.....	.....
Year:										
1881	.....	.....	8.60	.....	.....	.....	.....	.....	.....	16.44
1882	.....	.....	9.64	.....	.....	.....	.....	.....	.....	13.11
1883	.....	.....	10.57	.....	.....	.....	.....	.....	.....	12.38
1884	.....	.....	8.69	.....	.....	.....	.....	.....	.....	18.16
1885	.....	.....	4.24	.....	.....	.....	.....	.....	.....	8.11
1886	.....	.....	6.27	.....	.....	11.47	.....	.....	8.87	10.21
1887	.....	.....	8.19	.....	.....	15.28	.....	.....	11.73	13.53
1888	.....	.....	7.84	.....	.....	19.95	.....	.....	13.89	13.02
1889	.....	.....	7.78	.....	.....	15.39	15.87	.....	13.01	12.72
1890	.....	.....	13.83	.....	.....	19.60	.....	20.22	17.88	16.98
1891	8.59	.....	5.81	17.38	.....	10.84	12.04	14.34	11.50	10.63
1892	10.29	.....	.....	.....	.....	11.50	12.24	12.92	11.74	9.90
1893	8.37	.....	7.71	.....	.....	20.16	16.58	14.79	13.52	11.87
1894	15.12	18.36	4.57	.....	.....	13.95	16.48	.....	13.69	11.58
1895	15.92	14.44	.....	.....	.....	14.15	.....	14.80	14.82	13.26
1896	15.45	19.62	16.78	16.03	.....	21.27	20.39	20.86	18.62	15.93
1897	10.03	14.43	18.60	8.41	13.44	16.68	22.01	17.59	15.15	13.83
1898	14.96	20.89	.....	11.44	13.50	21.82	26.38	25.87	19.26	16.69
1899	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mean	12.34	17.55	9.21	13.31	13.47	16.31	17.75	17.67	14.13	13.24

nnual rainfall at stations in basin of Gila River, in the vicinity of Florence, Tucson, and Phenix, Arizona.

	Florence vicinity.			Santa Cruz Basin.					Phenix vicinity.			
	Buttes.	Florence.	Casa Grande.	Tucson.	Pantano.	St. Helena ranch.	Calabasas.	Lochiel.	Phenix.	Fort McDowell.	Pinal ranch.	Silver King.
Elevation	1,600	1,493	1,396	2,404	3,538	.....	3,445	5,100	1,068	1,250	4,400	3,800
Year:												
1867	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.26	.....	.....
1868	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.22	.....	.....
1869	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.69	.....	.....
1870	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.45	.....	.....
1871	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.94	.....	.....
1872	.....	.....	.....	.....	.....	.....	.....	.....	.....	20.01	.....	.....
1873	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.13	.....	.....
1874	.....	.....	.....	.....	.....	.....	.....	.....	.....	16.84	.....	.....
1875	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.97	.....	.....
1876	.....	9.33	.....	14.02	.....	.....	.....	.....	.....	7.73	.....	.....
1877	.....	5.35	.....	12.77	.....	.....	.....	.....	5.17	9.38	.....	.....
1878	.....	13.49	.....	16.66	.....	.....	.....	.....	8.52	11.92	.....	.....
1879	.....	12.02	.....	12.01	.....	.....	.....	.....	6.40	8.34	.....	.....
1880	.....	5.35	.....	6.61	.....	.....	.....	.....	6.82	6.61	.....	.....
1881	.....	12.14	1.73	14.92	15.65	.....	.....	.....	8.91	7.24	.....	.....
1882	.....	.....	.....	15.59	15.73	.....	.....	.....	6.94	9.10	.....	.....
1883	.....	.....	3.01	7.78	.....	.....	.....	.....	7.40	9.89	.....	.....
1884	.....	.....	9.71	15.03	.....	.....	.....	.....	12.83	20.95	.....	.....
1885	.....	.....	2.02	5.26	8.96	.....	.....	.....	3.77	8.30	.....	.....
1886	.....	.....	5.12	8.59	10.36	.....	.....	.....	5.78	8.08	.....	.....
1887	.....	.....	7.71	12.95	.....	.....	.....	.....	.....	10.32	.....	.....
1888	.....	.....	4.30	10.60	.....	.....	.....	.....	.....	11.91	.....	.....
1889	.....	8.90	4.25	18.37	15.50	.....	.....	.....	.....	12.78	.....	.....
1890	.....	12.70	10.70	14.16	18.71	.....	.....	26.90	.....	.....	.....	.....
1891	.....	8.24	3.62	7.30	9.87	.....	9.65	15.10	.....	.....	.....	.....
1892	.....	9.95	8.75	9.61	10.79	.....	11.83	.....	5.50	.....	.....	.....
1893	.....	9.63	4.92	13.12	3.35	.....	10.28	.....	7.68	.....	.....	.....
1894	.....	.....	5.82	7.29	18.84	.....	10.29	.....	5.50	.....	.....	.....
1895	.....	.....	.....	11.07	11.40	.....	15.14	.....	.....	.....	.....	.....
1896	.....	.....	.....	11.39	14.58	.....	.....	.....	10.48	.....	20.38	.....
1897	7.59	.....	3.03	10.77	10.73	18.21	10.83	16.14	9.87	.....	23.23	.....
1898	.....	.....	.....	12.72	12.16	.....	.....	.....	5.95	.....	19.84	.....
1899	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mean	.....	9.74	5.33	11.68	12.62	.....	11.34	19.38	7.35	10.48	21.15	.....

The records in the vicinity of Florence and Phenix apply to the districts where the water stored will probably be applied for irrigation, and indicate the need of an artificial supply. In the case of the San Pedro Basin, the greater portion of its water supply is furnished near the headwaters of that stream. The lower portion of the river, which constitutes the greater part of its area, being low in elevation, has a relatively lighter rainfall, and, owing to the flat nature of the valleys, a low per cent of run-off. The observations of precipitation in the San Pedro Basin have, with one exception—those of Dudleyville—been made in this upper portion of the basin and at points of high elevation. They indicate, therefore, a water supply in excess of conditions as they really exist.

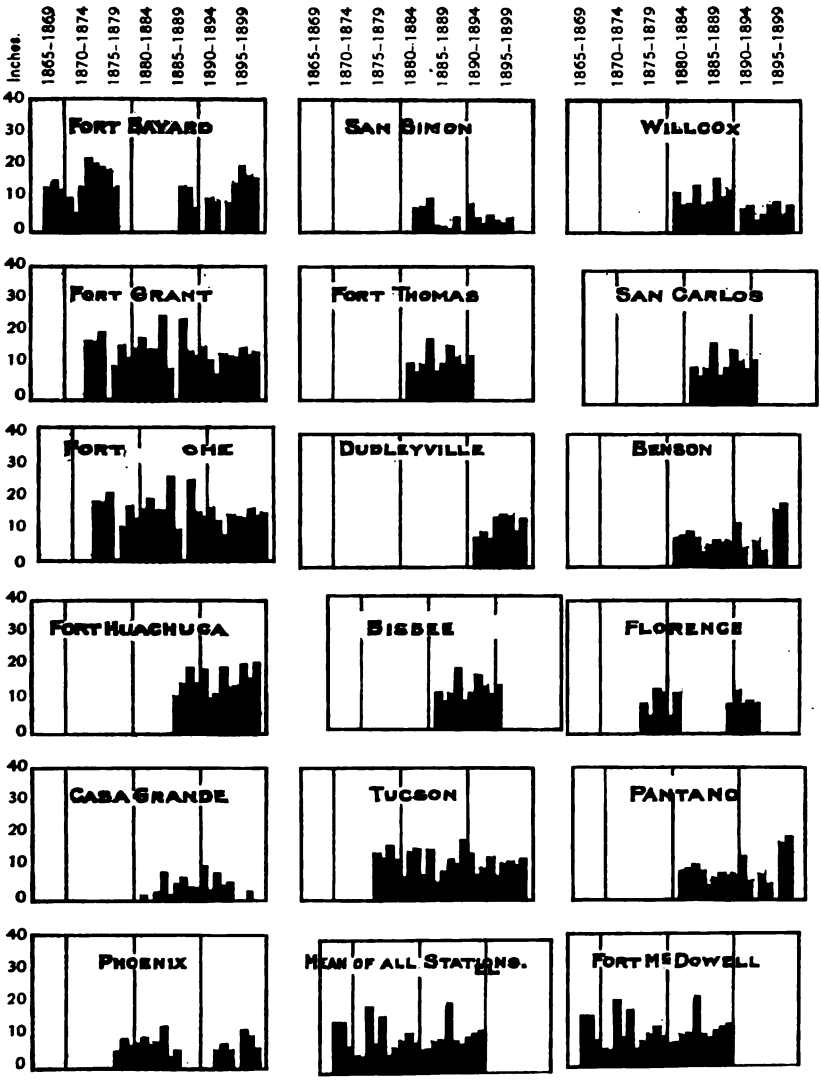
In connection with the study of the increase of rainfall with an increase in elevation, the following table is of interest:

Increase of rainfall with each 100 feet of rise in elevation, with Fort McDowell as a base.

Station.	Length of record.		Elevation.	Elevation above McDowell.	Measured rain.	Constant increase per 100 feet rise.
	Yr.	*mo.*	*Feet.*	*Feet.*	*Inches.*	*Inches.*
McDowell	23	10	1,250	.....	10.38	Base.
Lowell	19	5	2,400	1,150	12.37	0.17
Breckenridge	6	10	3,800	2,550	17.03	.26
Fort Grant	17	2	4,860	3,610	16.85	.18
Fort Buchanan	3	11	5,330	4,080	21.58	.27
Fort Apache	18	10	5,050	3,800	21.04	.28
Verde	22		3,160	1,910	13.13	.15
Prescott	23	11	5,390	4,140	17.06	.16
						1.47
Mean						.21

Comparing the stations given in this table with the record at Fort McDowell, which is a very old one, extending from 1867 to 1888, it is found that in eastern Arizona the rate of increase for each 100 feet of rise in elevation is 0.21 of an inch of rain. It is probable that, notwithstanding the fact that the mean rainfall as measured above San Carlos for all stations is 12.87 inches, and that the mean for the San Pedro Basin is given as 14.13, the average rainfall of the basin of the Gila above San Carlos is greater than the average for the entire San Pedro Basin, and consequently the run-off per square mile of the San Pedro Basin, owing particularly to the flat valley lands through which the river flows in the greater portion of its course, is less than the run-off per square mile of the Gila above San Carlos. This is sustained by observations of flow of both streams during a period of five months.

A diagram is given (Pl. IV) showing the precipitation, in inches per



ANNUAL RAINFALL AT EIGHTEEN STATIONS IN THE BASIN OF GILA RIVER.

annum, during the years when observations of the rainfall were made at various typical stations. For 1899 the figures are estimated after September 1. Data were had from the records of the Signal Service and of the Weather Bureau showing the amount of precipitation each month at each of the eighteen stations named in the table, but they are considered too voluminous for publication. The table of annual rainfall in the basin of the Gila is compiled from this mass of detail. After careful consideration it was deemed impossible to give an average rainfall for the basin based on probable rainfall at various elevations. The means given in the table and diagrams are the direct means of the stations at which observations were made, each being given equal weight in the years when its record occurs. In the case of the upper portion of the Gila the mean has not been extended back of 1881, as sufficient data do not exist upon which to base an accurate deduction. The few points at which observations were taken prior to 1881 would probably indicate a greater rainfall for the basin than existed, owing to their relatively great elevation. In like manner, the record of the San Pedro is not extended back of 1886.

SUBDIVISIONS OF THE DRAINAGE BASIN.

The outlines of the Gila River Basin have been marked on the Land Office maps of Arizona and New Mexico and the areas measured by planimeter. The basin of the southern tributary, the San Pedro, extends into the Republic of Mexico. From the best obtainable data the area in Mexico has been determined to be 120 square miles. The following table classifies the drainage basin of the Gila above the Buttes into three parts: First, the area above the San Carlos dam site, which would be tributary to a reservoir if located at that point; second, the area of the basin of San Pedro River; third, small intermediate basins below San Carlos. The San Pedro Basin is difficult of exact determination, owing to the excessive flatness of the Sulphur Springs Valley, extending from near Camp Grant to the Mexican line and varying from 30 to 40 miles in width. This valley is a great sink from which little or no run-off occurs, and it has been eliminated from consideration in this estimate south of the Graham County line. A small area between San Carlos and the Buttes is directly tributary to Gila River, independently of the San Pedro. The principal stream in this last-named district is Mineral Creek.

Drainage area of Gila River above the Buttes, Arizona.

		Square miles.
Drainage above San Carlos:		
In Arizona	7,378	
In New Mexico	6,077	
Total		13,455
San Pedro above mouth:		
In Arizona	3,336	
In Mexico	120	
Total		3,456
Small tributaries between San Carlos and the Buttes		923
Total area of Gila Basin above the Buttes		17,834
Total area below San Carlos		4,379

The total accepted area for the basin of Gila River above the Buttes is 17,834 square miles. The total area below San Carlos and above the Buttes is 4,379 square miles, which is practically 25 per cent of the entire area above the Buttes.

RELATIVE FLOW AT SAN CARLOS AND THE BUTTES.

In the Twelfth Annual Report of the Survey, Part II, page 305, is given a tabulation of the observations made on San Pedro River at its mouth, at Dudleyville, Arizona, from May to August, inclusive, 1890. During this period there was discharged from that stream 19,488 acre-feet of water. During the same period of time, as measured at the Buttes below the mouth of San Pedro River, there was a total discharge from the basin of 207,936 acre-feet. This shows that 9.4 per cent of the total discharge of the basin above the Buttes came from the San Pedro, and that 90.6 per cent came from other portions of the stream. There are 923 square miles tributary to the Gila above the Buttes and below San Carlos other than the San Pedro drainage.

From the above figures it is considered fair to estimate that 90 per cent of the water of Gila River comes from above San Carlos and that a reservoir located at the last-named point would only lose 10 per cent of the total amount flowing by the Buttes. Moreover, the amount which enters the stream below San Carlos would not necessarily be entirely lost to a reservoir at that point, as the discharge from the reservoir could be regulated, at least in part, so as to take advantage of the amount of water available from the San Pedro. The synchronous observations which have been made from July 19 to September 23, 1899, at San Carlos and at the Buttes have not yet been of sufficient duration to admit of drawing general conclusions.

During the month of July the record indicated that 91 per cent of the total flow at the Buttes passed San Carlos. During the month of August there was deficient rainfall throughout Arizona in general. According to the statement of the Weather Bureau (report for August, 1899, Arizona section), "The average precipitation for the Territory for the month of August was 85 per cent less than the normal. The average determined from the measurements of 59 stations was 1.26 inches, which is 1.75 inches less than the average for August, 1898. The greatest amount measured at any station during the month was 5.77, at Fort Huachuca, and no precipitation was reported at several stations." Fort Huachuca is in the headwaters of the basin of the San Pedro, and the rainfall at other stations in that neighborhood was abnormally large for August. As might be expected, therefore, during the month of August the discharge from the San Pedro has been proportionately great. The record of stream measurements indicates 60 per cent of the total flow as measured at the Buttes passing San Carlos during August. From September 1 to 23, inclusive,

there was 59 per cent at San Carlos. No rainfall records for September, 1899, are at present (October 3, 1899) available.

The record for the four months given in 1890 indicates 90 per cent of the total flow at the Buttes available at San Carlos, and during the two complete months (July 19 to September 23) when the measurements were maintained in 1899 at both places a mean of 74 per cent was available at San Carlos, or an average for the entire period of six months of 83 per cent at San Carlos.

The following figures are the result of comparative measurements at the Buttes and San Carlos during July, August, and September, 1899:

Comparative discharge of Gila River at San Carlos and the Buttes, in cubic feet per second.

	July.		August.		September.	
	San Carlos.	The Buttes.	San Carlos.	The Buttes.	San Carlos.	The Buttes.
1	.....	.....	780	1,850	80	60
2	.....	.....	3,188	2,850	80	50
3	.....	.....	960	4,100	80	45
4	.....	.....	780	2,260	80	42
5	.....	.....	520	1,040	80	24
6	.....	.....	520	930	230	31
7	.....	.....	590	660	290	1,300
8	.....	.....	460	1,380	7,920	10,187
9	.....	.....	680	905	780	2,923
10	.....	.....	520	717	520	1,950
11	.....	.....	370	460	410	1,382
12	.....	.....	330	515	330	734
13	.....	.....	330	397	290	510
14	.....	.....	260	397	230	399
15	.....	.....	260	280	200	357
16	.....	.....	200	215	200	288
17	.....	.....	200	315	200	249
18	.....	.....	140	210	200	205
19	11,976	1,800	140	270	170	202
20	6,568	8,700	140	175	140	147
21	2,174	4,100	140	135	110	130
22	1,836	2,260	140	100	110	126
23	1,836	1,900	110	112	110	99
24	1,498	1,550	110	90	.....	.....
25	960	1,445	110	89	.....	.....
26	780	1,550	110	80	.....	.....
27	840	1,550	80	80	.....	.....
28	750	3,640	80	70	.....	.....
29	960	2,440	140	71	.....	.....
30	590	2,475	80	60	.....	.....
31	520	995	80	77	.....	.....
Mean	2,407	2,647	405	671	555	932
Per cent	91	.....	60	.....	59	.....

The inspection and study of the basin of the San Pedro, as well as of the Gila proper, by members of this Survey, and the study made of the relative values of their drainage areas, justify the conclusion drawn from all the measurements that 90 per cent of the total flow as measured at the Buttes is available at San Carlos. The larger part of the water of Gila River comes from the San Carlos, the San Francisco, the Blue, and the extreme eastern branches of the stream, and a small per cent enters from the San Simon Plains, which lie between Solomonville and Bowie station on the Southern Pacific Company's railroad.

Wherever irrigation is practiced a certain portion of the water is permanently lost by evaporation from the surface of the ground or from the leaves of the growing plants. Another portion of the water used for irrigation, varying in amount from 20 to 50 per cent, depending upon the nature of the soil and the slopes of the irrigated lands toward the drainage lines, sinks into the ground. This is known as seepage or return water. It fills the pores in the soil, gradually raising the water plane until it flows into natural drainage lines and becomes again available for irrigation. In the Solomonville Valley, in the Gila River Narrows, below the Sanchez ditch, there was, on April 15, 1899, 237 second-feet of water. Within a distance of 40.7 miles below this point there was diverted in ditches 429.8 second-feet of water. A small amount of water is wasted back into the river from these ditches, but the actual amount used for irrigation is 64 per cent in excess of the amount available for that purpose at the highest point of diversion. In other words, an amount equal to 64 per cent of the water found at the head works on April 15, 1899, found its way through underground courses back into the river.

In the valley of the Salt River, near Phenix, there was 40 per cent more water used for irrigation in June, 1899, than was flowing in the river at the highest point of diversion at the head works of the Arizona Canal. It must be remembered in this connection, however, that during the months of July and August there is a much larger volume of water diverted for irrigation than on the dates when these measurements were made, and that a larger amount of water is used on other occasions for the irrigation of these lands than is indicated in this report.

In order to determine the actual ratio between the return water and the amount applied to irrigation the average annual quantity used for irrigation for a term of years should be determined. This amount is at present unknown. It is, however, fair to assume that a substantial percentage of all water used for irrigation finds its way back into the channel of the two streams named above. This may be as high as 25 per cent, as it is known to be greater in other localities. Because of the exceedingly slow movement through soil the discharge is regulated and is of a constant nature. For instance, the flow of Los Angeles River, in California, which receives its water supply from the sand and gravel beds of the San Fernando Valley, which underground reservoir is charged with intermittent floods, has not varied in amount during the last three years to exceed 15 per cent.

It may be confidently expected that as a result of the irrigation of 120,000 acres of lands in the Gila River Valley between Florence and Sacaton 20 or 25 per cent of the water used in this irrigation will return to the channel of Gila River and will be available for further use at lower points on this stream. This would be sufficient to irri-

A. BUTTES DAM SITE, LOOKING UPSTREAM; PROPOSED QUARRIES ON LEFT; SPILLWAY ON LEFT OF CENTER OF FIELD

B. BUTTES DAM SITE, LOOKING UPSTREAM FROM UPPER TOE.

gate from 24,000 to 30,000 acres of land, in addition to the areas estimated as capable of being served from a reservoir on Gila River.

MEASUREMENTS OF GILA RIVER AT THE BUTTES, ARIZONA.

Gila River leaves the mountains and enters the plains at a point 15 miles above Florence, known as the Buttes. At this place the river is in a canyon, which is approximately 450 feet wide, its bed being covered with sand and gravel to a maximum depth of 123 feet. Beyond this point, until it forms a junction with its principal tributary, Salt River, it loses in volume. A gaging station was established here and the amount of water available from the basin was accurately determined by the Geological Survey from August 26, 1889, to August 31, 1890, but the work was stopped at the end of this time by lack of available funds. The results of these measurements are given in the Twelfth Annual Report, Part II, Irrigation, pages 306 to 309, and following tables, and are shown graphically on Pl. VI, *B*. A gap occurs in the record from August, 1890, to August, 1895. In the fall of 1895 measurements were begun by the reestablishment of a station at the Buttes above Florence, at the same point that observations were made during the years 1889 and 1890.

From August 1, 1895, to December 10, 1895, gage heights and depths were observed by W. Richins, and occasional estimates of velocity were made, and with these data and the measurements made subsequent to the middle of December the daily discharge for the months of August, September, and November, and the early part of December, 1895, has been ascertained. These results can be regarded only in the light of approximations and do not compare in value with those following December 10. Measurements were continued throughout the year 1896 by W. J. Brash, daily readings of the gage being taken and current-meter measurements made from one to three times a week. The data obtained for the period following December 10, 1895, and extending to October, 1896, are of a high degree of accuracy.

During the year 1897 measurements were continued at this station by W. J. Brash and Albert T. Colton, forty-nine measurements of discharge being taken, the last measurement being made on October 24, 1897. Mr. Brash, who was connected with this work in 1896 and 1897, died in the fall of 1897, and no other person residing in that immediate locality, it was not possible, with funds available, to have the gage rod read daily.

Measurements were made between March 7 and October 10, 1898, by Albert T. Colton, and subsequent to November 14 by Cyrus C. Babb and others connected with the present investigation. Sixteen meter measurements of discharge were thus made, as shown by the diagram, Pl. VI, *B*, prior to November 25, 1898. After this time a contin-

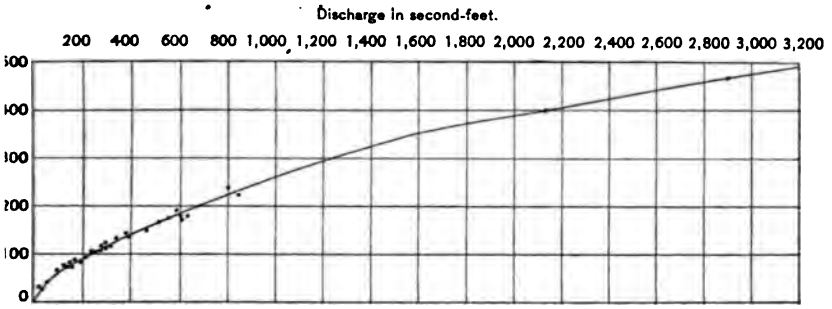
uous record was maintained to the end of the year. In order to make the best possible use of the sixteen observations made prior to November 25, 1898, the volumes as measured on those dates were plotted in diagram, the vertical axis representing volumes measured in cubic feet per second and the horizontal axis representing intervals of one day's time each. The points thus determined were connected by straight lines, and from this diagram monthly estimates of discharge were made. Subsequent to November 25, 1898, daily observations of gage height and area were taken and frequent meter measurements of volume made. As daily measurements of areas in square feet were made, the rating curve graphically shown on Pl. VI, *A*, is in terms of areas of cross section and discharge.

During the year 1899, until October 20, measurements of area were made daily and frequent observations of velocity were taken with a meter. The results are shown graphically on Pl. VI, *B*. The rating table applying from November 25, 1898, to July 10, 1899, is used for the first portion of this year. The meter which was in service at the Buttes got out of order July 20, 1899, and until August 10 observations of gage height and area were taken daily. The discharge during this interval has been computed by using values corresponding to the gage heights determined from the rating curve shown on Pl. VIII, *A*. This exhibits the relation between gage height and discharge, and also, by the position of the small dots, the values determined by meter measurements. The following table expresses numerically the values given in the rating curve:

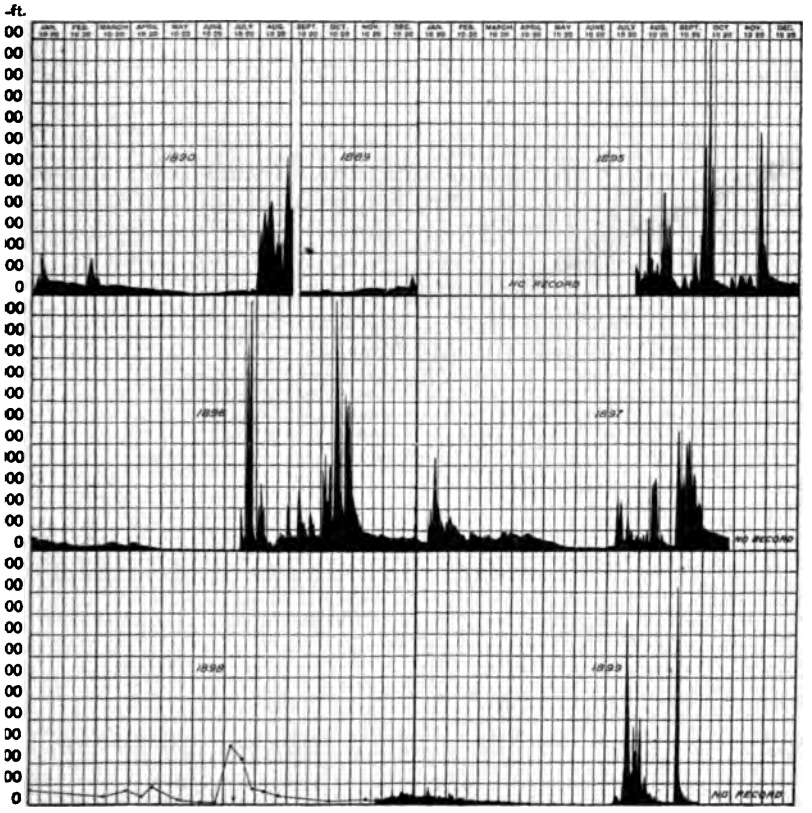
Rating table for Gila River at the Buttes, Arizona, from July 11, 1899, to August 10, 1899.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
	Sec.-ft.		*Sec.-ft.*		*Sec.-ft.*		*Sec.-ft.*
1.5	----------	2.7	250	3.9	1,445	5.1	3,364
1.6	0	2.8	320	4.0	1,550	5.2	3,548
1.7	1	2.9	410	4.1	1,670	5.3	3,732
1.8	5	3.0	500	4.2	1,800	5.4	3,916
1.9	9	3.1	605	4.3	1,950	5.5	4,100
2.0	15	3.2	710	4.4	2,100	6.0	5,020
2.1	25	3.3	815	4.5	2,260	6.5	5,940
2.2	40	3.4	920	4.6	2,440	7.0	6,860
2.3	60	3.5	1,025	4.7	2,625	7.5	7,780
2.4	90	3.6	1,130	4.8	2,810	8.0	8,700
2.5	130	3.7	1,235	4.9	2,995	8.5	9,620
2.6	180	3.8	1,340	5.0	3,180	9.0	10,540

From these daily measurements of area and frequent measurements of discharge, together with the rating tables mentioned above, the following table of volumes of discharge for Gila River at the Buttes from November 25, 1898, to September 30, 1899, has been prepared.



A. RATING CURVE OF GILA RIVER AT THE BUTTES, ARIZONA. APPLIED FROM NOVEMBER 25, 1898, TO JULY 10, 1899.



B. DISCHARGE OF GILA RIVER AT THE BUTTES, ARIZONA, 1889–1899.

Estimated daily discharge of Gila River at the Buttes.

	1898.				1899.							
	November.		December.		January.		February.		March.		April.	
	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.
	.....	.....	2.32	195	2.80	320	2.69	170	2.50	125	2.50	90
	.....	.....	2.35	195	2.775	345	2.72	200	2.50	155	2.45	90
	.....	.....	2.35	215	2.80	370	2.88	550	2.50	155	2.50	90
	.....	.....	2.40	255	2.72	255	2.94	455	2.50	110	2.50	100
	.....	.....	2.40	235	2.70	300	2.90	345	.....	110	2.50	100
	.....	.....	2.40	255	2.65	275	2.77	410	2.50	110	2.50	100
	.....	.....	2.45	255	2.60	255	2.69	235	2.50	155	2.45	80
	.....	.....	2.45	255	2.62	275	2.71	235	2.50	155	2.45	70
	.....	.....	2.50	275	2.67	255	2.72	200	2.50	110	.....	60
	.....	.....	.....	275	2.60	235	2.70	300	2.50	140	2.45	60
	.....	.....	2.60	275	2.72	275	2.77	255	2.40	140	2.45	50
	.....	.....	2.72	410	2.95	480	2.80	300	.....	140	2.40	70
	.....	.....	2.50	300	3.30	800	2.80	275	2.40	140	2.40	70
	.....	.....	2.70	320	3.15	500	2.77	275	2.40	100	2.40	70
	.....	.....	2.75	275	3.00	435	2.75	275	2.40	100	2.40	60
	.....	.....	2.72	320	3.00	390	2.70	255	2.50	100	.....	60
	.....	.....	2.80	320	2.95	345	2.67	170	2.55	110	2.40	60
	.....	.....	2.85	390	2.92	345	2.67	170	2.55	155	2.40	60
	.....	.....	2.90	480	2.80	320	2.66	140	.....	155	2.35	60
	.....	.....	2.90	480	2.72	275	2.62	170	2.60	155	2.30	50
	.....	.....	2.87	435	2.70	255	.....	170	2.60	155	2.30	60
	.....	.....	2.90	410	2.70	235	2.65	170	.....	140	2.30	50
	.....	.....	2.90	435	2.80	320	2.60	155	2.60	140	.....	50
	.....	.....	2.95	390	2.80	370	2.60	200	2.50	140	2.30	60
	2.10	105	.....	335	2.75	255	2.60	155	2.50	140	2.30	50
	2.20	165	2.80	275	.....	300	2.60	155	.....	140	2.30	40
	2.20	135	2.80	300	2.75	235	2.60	170	2.50	125	2.30	20
	2.10	165	2.85	345	2.70	255	2.50	125	2.50	110	2.25	30
	2.22	150	2.75	320	2.75	235	.....	.....	2.50	125	2.25	30
	2.30	195	2.80	300	2.70	170	.....	.....	2.50	110	.....	30
	.....	.....	2.80	320	2.70	185	.....	.....	2.50	100	.....	.....
n	.....	152	.....	305	.....	318	.....	239	.....	130.5	.....	62.3

	May.		June.		July.		August.		September.	
	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.	Gage height.	Dis-charge.
	2.25	38	1.90	5	1.75	0.5	4.0	1,850	2.0	60
	2.20	34	2.20	30	1.75	0.5	4.7	2,850	2.0	50
	2.20	30	2.10	20	1.70	0.5	5.5	4,100	.....	45
	2.20	30	.....	16	1.70	0.3	4.5	2,260	1.9	42
	2.20	31	2.00	12	1.70	0.3	4.0	1,040	1.9	24
	2.15	28	1.95	11	1.70	0.3	3.7	930	1.9	31
	.....	26	1.90	16	1.70	0.2	3.3	660	3.28	1,300
	2.15	25	1.90	6	1.70	0.2	4.5	1,380	8.3	10,187
	2.15	24	1.90	5	.....	0.2	3.7	905	4.95	2,923
	2.10	24	1.85	5	1.80	2	3.3	717	4.3	1,950
	2.10	24	.....	4	2.75	300	3.3	460	3.5	1,382
	2.10	23	1.80	4	2.80	320	3.1	515	3.0	734
	2.10	23	1.80	2	2.70	250	2.8	397	2.8	510
	.....	20	1.80	2	2.50	130	2.8	397	2.7	399
	2.05	16	1.80	2	2.40	90	2.7	280	2.6	357
	2.05	14	1.75	2	.....	170	2.6	215	2.5	288
	2.00	12	1.75	1	2.70	250	2.5	315	2.4	249
	2.00	13	.....	1	3.40	920	2.5	210	2.3	205
	2.00	13	1.75	1	4.20	1,800	2.4	207	2.3	202
	2.00	14	1.75	1	8.00	8,700	2.4	175	2.2	149
	.....	12	1.75	1	5.50	4,100	.....	135	2.2	130
	2.00	10	1.75	1	4.50	2,260	2.3	100	2.2	126
	2.00	8	1.75	1	.....	1,900	2.3	120	2.1	99
	2.00	9	1.75	1	4.00	1,550	2.2	90	2.1	108
	2.00	11	.....	1	3.90	1,445	2.1	89	2.05	93
	2.00	12	1.75	2	4.00	1,550	2.1	80	2.0	72
	1.95	13	1.75	2	4.00	1,550	2.1	80	2.0	77
	.....	10	1.75	1	5.25	3,640	2.0	70	2.0	68
	1.95	9	1.75	1	4.50	2,440	2.0	71	2.0	68
	1.90	6	.....	.....	4.20	2,475	2.0	60	.....	68
	1.90	4	.....	.....	4.00	990	2.0	77	.....	.....
n	.....	18.2	.....	5.4	.....	1,188.0	.....	671.8	.....	733.1

Estimated monthly discharge of Gila River at the Buttes, Arizona.

[Drainage area, 17,834 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second feet per square mile.
1889.						
September	210	90	128	7,616	0.010	0.009
October	210	140	157	9,655	0.013	0.011
November	250	156	212	12,614	0.017	0.015
December	890	124	275	16,909	0.023	0.020
1890.						
January	2,100	310	680	41,812	0.056	0.049
February	1,514	405	578	32,100	0.043	0.042
March	710	300	387	23,795	0.032	0.028
April	333	158	238	14,161	0.019	0.017
May	150	35	87	5,350	0.207	0.206
June	35	27	28	1,666	0.002	0.002
July	3,112	11	130	7,995	0.010	0.009
August	6,330	1,115	3,137	192,888	0.263	0.228
Total for season 1889-90			503	366,561	0.447	
1895.						
August	3,910	536	1,583	97,336	0.133	0.115
September	2,880	300	812	48,317	0.065	0.059
October	12,000	400	1,577	96,966	0.133	0.115
November	7,500	300	1,103	65,633	0.089	0.080
December	1,150	518	751	46,177	0.056	0.055
Total				354,429		
1896.						
January	560	250	396	24,349	0.032	0.028
February	340	175	209	12,027	0.016	0.015
March	356	153	242	14,880	0.021	0.018
April	340	68	180	10,711	0.014	0.013
May	68	12	32	1,968	0.002	0.002
June	32	1	5	298	0.000	0.000
July	11,708	1	1,441	88,604	0.121	0.105
August	3,150	175	810	49,805	0.068	0.059
September	2,850	455	980	58,314	0.079	0.071
October	11,793	1,030	4,145	254,868	0.347	0.301
November	2,275	696	1,037	61,706	0.083	0.075
December	710	576	629	38,676	0.053	0.046
Per annum	11,793	1	842	616,206	0.839	0.062
1897.						
January	4,310	400	1,286	79,074	0.108	0.094
February	1,580	560	883	49,039	0.066	0.064
March	920	520	702	43,165	0.059	0.051
April	800	520	694	41,296	0.056	0.050
May	440	94	224	13,773	0.018	0.016
June	83	20	52	3,094	0.004	0.004
July	2,360	00	565	34,741	0.047	0.041
August	3,270	160	799	49,129	0.067	0.058
September	5,590	106	2,371	141,084	0.192	0.172
October			800	49,190	0.067	0.058
				503,585		
1898.						
January			640	39,352		
February			485	26,936		
March			473	29,083		
April			547	32,549		
May			292	17,954		
June			252	14,995		
July			2,022	124,328		
August			537	33,018		
September			270	16,066		
October			79	4,858		
November			101	6,010		
December	480	195	305	18,753		
				363,902		

Estimated monthly discharge of Gila River at the Buttes, Arizona—Continued.

[Drainage area, 17,834 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1899.						
January	800	170	318	19,552	0.0209	0.0178
February	550	125	239	13,273	0.0135	0.0130
March	155	100	130.5	7,993	0.0080	0.0070
April	100	20	62.3	3,689	0.0040	0.0036
May	38	4	18.2	1,107	0.0010	0.0010
June	30	1	5.4	307	0.0003	0.0003
July	8,700	0.2	1,188.2	73,060	0.0767	0.0666
August	4,100	60	671.8	41,307	0.0437	0.0376
September	10,187	24	733.1	43,622	0.0460	0.0411
	.....	.....	.....	203,910	0.2141	.....

From the foregoing data the following tables of annual discharge of Gila River at the Buttes and at San Carlos have been compiled:

Estimated annual discharge of Gila River at the Buttes and San Carlos, Arizona.

	Buttes.	San Carlos.[a]
	Acre-feet.	*Acre-feet.*
Seasonal year 1889–90, Sept. 1 to Aug. 31	366,561	329,905
Fractional year 1895, Aug. 1 to Dec. 31	354,429	318,986
Year 1896	616,206	554,585
Fractional year 1897, Jan. 1 to Oct. 3	503,585	453,227
Year 1898, approximate	363,902	327,512
Fractional year 1899, Jan. 1 to Sept. 30	203,910	183,519

[a] Ninety per cent of volume at the Buttes.

In order to get the greatest possible value from the records which have been compiled, and more particularly to make comparison with the annual rainfall records, the table given below has been prepared. In this statement every month in which measurements were taken is considered in the determination of an average monthly discharge for each month of the year. There are sixty months in all during which observations were made, there being five different years in which the flow was observed between January and September, inclusive, and four years in which November and December observations were made. From this table the mean monthly discharge is determined, and where a year has seven or more months of measured record, the remaining portion of it being deficient, the mean monthly discharge, as determined, is substituted for the months in which the record is defective. In this way a complete estimated record for five years is obtained, four months having been supplied for the year 1890, two for the year 1897, and three for the present year, 1899. A mean annual discharge is obtained by adding the mean monthly discharges actually measured, so that the mean annual discharge, which is 485,545 acre-feet, is *determined only from actual measurements*, and includes

all measurements that have been made. According to the census of 1890, there were but 6,619 acres irrigated from this great water supply, or less than 3 per cent of its possible utility. Practically the same area is irrigated at present as in 1890.

Estimated monthly mean, annual, and mean annual discharge, in acre-feet, of Gila River at the Buttes, Arizona.

[Drainage area, 17,834 square miles. Sixty months of observation.]

Year.	January.	February.	March.	April.	May.	June.
1890	41,812	32,100	23,795	14,161	5,350	1,666
1896	24,349	12,027	14,880	10,711	1,968	298
1897	79,074	49,039	43,165	41,296	13,773	3,094
1898	39,352	26,936	29,083	32,549	17,954	14,995
1899	19,552	13,273	7,998	3,689	1,107	307
Mean	40,828	26,675	23,783	20,481	8,030	4,072

Year.	July.	August.	September.	October.	November.	December.	Total.
1889	.....	.....	7,616	9,655	12,614	16,909	.....
1890	7,995	192,888	a52,503	a83,109	a36,491	a30,129	523,775
1895	.....	97,336	48,317	96,966	65,633	46,177	.....
1896	88,604	49,805	58,314	254,868	61,706	38,676	616,206
1897	34,741	49,129	141,084	49,190	a36,491	a30,129	570,205
1898	124,328	33,018	16,066	4,858	6,010	18,753	363,902
1899	73,060	41,307	43,622	a83,109	a36,491	a30,129	353,639
Mean	65,745	77,247	52,503	83,109	36,491	30,129	469,093

a Approximate.

Using the data obtained from the above table to determine the probable conditions which would exist at San Carlos and at the Buttes, the table given below has been prepared. The amount of water measured at the Buttes is the basis of comparison, 90 per cent of the volume being taken as available at San Carlos during the years in which the observations were made. This table is given in order to determine the proper heights of dams to be constructed either at San Carlos or at the Buttes. From the volumes available annually have been deducted the contents of the reservoirs with the dams agreed upon for consideration in this report, and a column both for the Buttes and for San Carlos is given, showing the surplus water each year.

Volume, in acre-feet, available at the Buttes and at San Carlos, and surplus above capacity of respective reservoirs.

[Capacity of the Buttes reservoir, 174,040 acre-feet. Capacity of San Carlos reservoir, 241,396 acre-feet.]

Year.	The Buttes.		San Carlos.	
	Available.	Surplus.	Available.	Surplus.
1890	523,775	349,735	471,398	230,002
1896	616,206	442,166	554,585	313,190
1897	570,205	396,165	513,185	271,789
1898	363,902	189,862	327,512	86,116
1899	353,639	179,599	318,275	76,879
Mean	469,093	295,053	422,184	180,788

In order to make a comparison between the years in which observations of volumes discharged at the Buttes were made and years in which rainfall records were taken in the basin of Gila River, the diagram on Pl. III, *B*, is given. The rainfall data for this diagram is taken from the summary given on page 19, and is the mean for the entire basin of Gila River above the Buttes. The record begins in 1881 and extends to 1899, inclusive, covering eighteen years of rainfall record, that for 1899 being estimated for the period after September 1. Below the record of rainfall, which is in inches of depth, is given, for corresponding years, the volume discharged in acre-feet. It is desirable to determine whether years in which discharge measurements were made were years of excessive or deficient rainfall. It will be seen that the year 1897 is one of approximately average rainfall, and that in this year twice as much water was available for storage, either at San Carlos or at the Buttes, as the reservoirs could hold. The year 1898 was one of excessive rainfall, but it shows less run-off than the year 1897. This is probably accounted for by the nature of the storms occurring in the basin during that period, a greater portion of the water being absorbed by the ground and evaporated in 1898. The run-off from a hard rain is relatively higher than the run-off resulting from a slow rain or a gentle shower.

There is no record of discharge for the years of markedly deficient rainfall, unless it be the present year, 1899, for which the record is incomplete. During the first eight months of the year 1899 the rainfall for the portion of the basin above San Carlos was 6.40 inches, or 75 per cent of the mean. During this same period the precipitation for the San Pedro stations was 96 per cent of the mean. To August 1 the rainfall for the entire basin was 80 per cent of the usual precipitation. This would indicate for the present year a probable mean rainfall of 10.59 for the basin. The year for which we have the lowest record, as determined by our table, is 1885, when the average rainfall for the basin was 8.11 inches. This comparison is quite rough, but it gives some idea of the general conditions.

It will be seen from the above that the year 1899 is among the years of low run-off and rainfall. Numerous people were asked concerning the relative dryness of the year 1899 in Arizona. There was a unanimous verdict expressed to the effect that it was the driest year which they have had in the last ten, as regards both rainfall and the amount of water in the streams. From the table of volumes available at the Buttes and at San Carlos, the surplus which is estimated for the year 1899 is seen to be 179,599 acre-feet at the Buttes and 76,879 acre-feet at San Carlos. There is still a margin for drier years than the ones through which we have just passed.

It is, of course, impossible to predict absolutely that either of the reservoirs as projected would always be filled, but there is probability, if not certainty, that in all ordinary years, in all years of excessive rainfall, and in *all years of ordinary* drought the reservoirs will be

more than filled, and that only in conditions of excessive drought, surpassing those of record and of memory, is there a possibility that the reservoir as planned either at the Buttes or at San Carlos will not be completely filled. Even should it not be completely filled, it is certain that a partial supply will always be available, so that the irrigated lands supplied from this source can readily be brought through one season of drought without serious damage. These periods of excessive drought are not likely to occur oftener than once every fifteen years.

From the data and tables given in the previous paragraphs, it is considered that, as far as the water supply is concerned, a dam 170 feet high at the Buttes, storing 174,040 acre-feet of water, or a dam 130 feet high at San Carlos, storing 241,396 acre-feet of water, can be built with every assurance of success. The statement is ventured that there are no reservoirs in arid America that have a more certain water supply, proportional to their capacity, than these proposed reservoirs on the Gila River.

EVAPORATION.

In the Twelfth Annual Report of the Survey, page 308, there is given a table showing the probable monthly evaporation from a water surface in Arizona, from observations made in the Southwest by the Survey. This is accepted as the basis of estimates for evaporation in this report:

Loss by evaporation from a water surface.

Month.	Quantity.	Month.	Quantity.
	Inches.		*Inches.*
January	3	August	13
February	4	September	10
March	6	October	6
April	7	November	5
May	10	December	4
June	11		
July	12	Total	91

It is obvious that in order to obtain an approximate idea of the loss by evaporation from a reservoir, an estimate must be made of the area that will be exposed to evaporation. For this purpose the following table has been prepared. It is assumed that 100,000 acre-feet of water should be in the Buttes reservoir at the end of the irrigation season, or on November 1, of each year. The amount of water, in acre-feet, that will probably flow into the reservoir during November has been obtained from the table of the estimate of monthly mean, annual, and mean annual discharges of the river at the Buttes. The amount of inflow for each month is added to the amount of water available from the previous months. The annual consumption from the reservoir is assumed to be the capacity of a completely filled reservoir, which in the case of the Buttes is 174,040 acre-feet. The amount of this water consumed each month has been estimated in the column marked "Portion of reservoir used."

It is assumed that a certain amount of water will always be required in the canals, even in winter time, for the irrigation of annual plants and to provide for domestic and stock water. The fifth column of the table is entitled "Outflow for irrigation," and is given for each month of the year. This is obtained by multiplying the annual consumption by the per cent used each month. This monthly consumption is deducted from the amount available in the reservoir at the end of each month, and from these figures the mean area of the water surface in the reservoir each month is obtained and given in column six, entitled "Area exposed to evaporation." The depth of evaporation for each month is then taken from the above, and the resulting loss by evaporation is shown in the eighth column, entitled "Loss by evaporation." The next column shows the total loss from the reservoir from evaporation and irrigation; the tenth column, the remainder in the reservoir at the end of each month, and the eleventh column, the amount that is wasted from a full reservoir, the capacity of the reservoir being 174,040 acre-feet, and the annual outflow of the basin at the Buttes being estimated as 469,093 acre-feet, as shown in the table on page 30. In an average year the total waste is 198,590 acre-feet of water.

The loss by evaporation under the above conditions would be 22,370 acre-feet, but there still would be available from the reservoir for irrigation its full capacity of 174,040 acre-feet of water. It is of interest to note that under the above conditions there never would be less than 132,320 acre-feet of water in the reservoir, which is sufficient to provide for a complete summer irrigation, in case the stream should be entirely dry for a period of five months.

Hypothetical summary of amount of water in the Buttes reservoir each month, with use, evaporation, and surplus.

Month.	Contents of reservoir at beginning of month.	Inflow.	Portion of reservoir used.	Outflow for irrigation.	Area exposed to evaporation.	Depth of evaporation.	Loss by evaporation.	Total loss from evaporation and irrigation.	Balance in reservoir at end of month.	Amount wasted over dam.
	Acre-ft.	*Acre-ft.*	*P. ct.*	*Acre-ft.*	*Acres.*	*Feet.*	*Acre ft*	*Acre ft*	*Acre-ft.*	*Acre-ft.*
November	100,000	36,500	2	3,480	2,350	0.42	990	4,470	132,030	.....
December	132,030	30,100	2	3,480	2,800	.333	700	4,180	157,950	.....
January	157,950	40,800	2	3,480	3,070	.25	770	4,250	174,040	20,460
February	174,040	26,700	5	8,700	3,150	.333	1,050	9,750	174,040	16,950
March	174,040	23,800	7	12,180	3,150	.50	1,580	13,760	174,040	10,040
April	174,040	20,500	9	15,660	3,150	.58	1,830	17,490	174,040	3,010
May	174,040	8,030	14	24,370	3,000	.833	2,500	26,870	155,200	.....
June	155,200	4,070	14	24,370	2,800	.92	2,580	26,950	132,320	.....
July	132,320	65,740	13	22,630	2,770	1.00	2,770	25,400	172,660	.....
August	172,660	77,200	13	22,630	3,150	1.08	3,400	26,030	174,040	49,790
September	174,040	52,500	11	19,140	3,150	.833	2,620	21,760	174,040	30,740
October	174,040	83,100	8	13,920	3,150	.50	1,580	15,500	174,040	67,600
Total	.....	469,040	100	174,040	.....	7.58	22,370	196,410	.....	.....

As the conditions above named are all assumed, the figures used are round numbers. It is probable that a more complete knowledge of the stream will permit of a greater annual consumption by irrigation than the capacity of the reservoir alone would indicate. The driest year of which we have any record would permit the use of 174,040 acre-feet of water from the Buttes reservoir, with a substantial reserve.

Accurate observations of evaporation are always difficult to obtain, owing to variation in wind velocities and general exposure of the evaporating pan. The effort should be made to have conditions in the evaporation pan that would be similar to those existing in the reservoir, from which the loss from this source is to be determined. For this reason it is necessary to float the evaporation pan in the river or in a canal, and the fluctuations of the water surface are often so great that the pan is frequently either upset or entirely lost. Rain falling on the pan has also to be considered, and it is known that the amount of catchment in a pan 3 feet square is relatively larger than the catchment in a standard rain gage, the diameter of whose cup is 8 inches. In the Twelfth Annual Report of the Survey, page 235, is given a statement of some evaporation observations made in the Southwest. These do not cover complete months and may be misleading.

Observations of evaporation from graduated tubes were made at the Buttes from January to July, 1899. These tubes were exposed in the shade, and the wind was prevented from acting directly on the water's surface. The results obtained are of doubtful value and are not used. In July, 1899, an evaporating pan was floated in the river at the Buttes, but the record was so much interfered with by high water upsetting the pan that it is considered unreliable. Later the attempt was made to float the pan in an artificial pond.

SPILLWAY PROVISIONS.

The accompanying illustrations, Pls. V, IX, and XII, exhibit the conditions at the Buttes dam site, and show the principal features of the proposed spillway. In the report by Mr. Davis, of 1896, he determined the maximum flood that would have to be provided for at the dams in this stream, as follows:

The first consideration in plans for a dam under the circumstances here presented is the provision for a safe and adequate spillway. The large catchment area of this stream, its mountainous character, the paucity of soil and vegetation on these mountains, exposing considerable area of bare rock on steep slopes, and the sudden and violent nature of the summer rainstorms indicate the necessity of a spillway of large proportions. What this capacity should be is recognized as one of the important and difficult problems. The best evidence thus far obtained regarding past freshets on this river was kindly furnished by Mr. Albert T. Col-

ton. The greatest rise so far recorded on the Gila River occurred on the 23d of February, 1891. Considerable evidence was obtained that no such flood has occurred since a date many years before the advent of the white man. Irrigating ditches supposed to be extremely old were overflowed and destroyed. Lands were overflowed that had retained no evidence of any previous inundation.

On June 12, 1892, about sixteen months after this flood, Mr. Colton found marks of high water on both banks of the river far above any of the ordinary freshets, which he attributed to the great flood. This point was about 3½ miles below the head of the Florence canal, or approximately 6 miles below the Buttes. With his level he took a cross section of the river at this point and measured the slope of the channel. The cross section he obtained was 6,600 square feet. The slope measured was 10.56 feet per mile. The channel was sandy and free of brush or large bowlders or other obstructions for a distance of 300 feet above and 300 feet below the cross section. This information, meager as it is, is the best we have upon which to estimate the discharge of the river at that time.

The difficulty in obtaining correct results of this discharge lies in the uncertainty of the retarding effect of the channel upon the flow of the water. This retarding effect in a rough river bed is very great. Assuming this quantity as small as it could possibly be, a computation of the discharge was made, using Kutter's formula. The factor of roughness designated in the formula as "*n*" was taken as 0.025. Not that this was considered the correct factor, as it is almost certainly too small, but by assuming the smallest possible value of "*n*" we obtain the largest discharge, and it is the largest discharge that should be provided for in the construction of a spillway. It is thought, therefore, that this computation will give conservative results, and that a spillway based upon the discharge obtained would be safe. The result obtained was 102,566 cubic feet per second. And it is to accommodate this discharge that the spillway is planned. It will be seen at once that no such spillway could be economically provided artificially, and that the accommodation of the topography to the provision of this spillway is one important determining feature of the location and height of the dam.

SILT.

The following further quotation is made from the same report of Mr. Davis:

The amount of solid material carried by such a stream as the Gila can be learned only by impounding it. As it is considerable, it is obvious that a reservoir built on this water course will eventually fill with solid matter unless means are provided for its removal. No entirely sufficient plan for this purpose has ever been put in operation. It is usually assumed, and often with truth, that the life of the reservoir is sufficiently long to justify its construction even though it will eventually fill and have its usefulness destroyed. This disposition of the problem, however, is not applicable to the present case. The amount of material carried by this stream is too large and the necessity of the reservoir to the life of the district to be irrigated from it is too vital to justify this convenient solution or, rather, evasion of the problem.

The most astonishing accounts are obtained from the inhabitants of this region of the quantity of silt carried in suspension by this stream when in flood. Many people in their emphatic expressions place the quantity at one-half the volume, though, of course, this is impossible. It is said, however, that in the months of July and August, when the surface of the ground is exceedingly dry, when it has been ground to powder even in the most isolated and apparently inaccessible

localities by range cattle and horses in search of grass, when the great torrential "cloud-bursts," to which this country is subject, fall upon such ground and rush off the steep slopes into the stream with prodigious velocity, the amount of silt carried in suspension by the roaring torrent is very great.

* * * * * * *

Attempts have been made, however, by private parties from time to time to measure the amount of suspended material. The most important and reliable of these measurements were those made by Mr. Albert T. Colton in the month ending August 7, 1893, and by Mr. W. Richins at the Buttes. Mr. Colton found the percentage of silt by volume averaged 2.2 per cent. As these observations were taken and reduced by Mr. Colton, who is a competent engineer, they are adopted as correct. The observations by Mr. Richins extended from July 29 to December 31, 1895. They were taken by the following method:

A sample of the water was poured into a slender glass tube until it reached the height of 100 divisions on a convenient scale, and was then allowed to settle several days, until the main portion of the water was clear. The height of the sediment on the same scale was then read and the result recorded as the percentage of mud carried by the water. The existence of this record, and the ease with which more of such observations could be taken, made it important that an approximate relation be established between the volume of this mud and that of the actual solid matter it contained. For this purpose several laboratory determinations have been made with muddy samples of Gila water by settling and reading the volume of mud as above and then drying the residue at 100° C. and determining its volume.

These observations indicate an average ratio of dry matter to mud of about one-fifth, and this factor has been used to reduce the mud observations of Mr. Richins to solid matter.

* * * * * * *

It should be remembered that these observations take no account of material that is rolled on the bottom of the stream.

On page 32 of Mr. Davis's report of 1896 a table is given showing the percentage of mud and solid matter carried each day from July 29 to December 31 in Gila River at the Buttes. The following table gives, in columns Nos. 3 and 4, this percentage of mud and of solids. In column No. 2 the number of acre-feet discharged on corresponding dates is given, and columns Nos. 5 and 6 give the number of acre-feet of mud and solids for the same dates. During this period the volume of water discharged at the Buttes was 360,523 acre-feet, and from the table it is found that 37,984 acre-feet of mud was carried in suspension by this water. This, reduced by the ratio of 5 to 1, as adopted by Mr. Davis, gives 7,704 acre-feet of solids. The average amount of mud during this period is 10.5 per cent.

Discharge of sediment of Gila River at the Buttes for 1895.

[Observer, W. Richins.]

Day.	July.					August.				
	Water.	Mud.	Solids.	Mud.	Solids.	Water.	Mud.	Solids.	Mud.	Solids.
	Acre-ft	*Per ct.*	*Per ct.*	*Acre-ft*	*Acre-ft*	*Acre-ft*	*Per ct.*	*Per ct.*	*Acre-ft*	*Acre-ft*
1	.....	.....	.....	.....	.....	1,161	15	3.0	159	32
2	.....	.....	.....	.....	.....	1,631	20	4.0	326	65
3	.....	.....	.....	.....	.....	1,505	20	4.0	301	60
4	.....	.....	.....	.....	.....	2,479	20	4.0	496	99
5	.....	.....	.....	.....	.....	1,733	20	4.0	347	69
6	.....	.....	.....	.....	.....	1,806	20	4.0	361	72
7	.....	.....	.....	.....	.....	1,956	15	3.0	293	59
8	.....	.....	.....	.....	.....	6,861	20	4.0	1,372	274
9	.....	.....	.....	.....	.....	3,247	15	3.0	487	97
10	.....	.....	.....	.....	.....	3,406	15	3.0	511	102
11	.....	.....	.....	.....	.....	3,326	15	3.0	499	100
12	.....	.....	.....	.....	.....	2,554	12	2.4	307	61
13	.....	.....	.....	.....	.....	2,273	7	1.4	159	32
14	.....	.....	.....	.....	.....	2,475	7	1.4	173	35
15	.....	.....	.....	.....	.....	2,178	7	1.4	152	30
16	.....	.....	.....	.....	.....	3,168	7	1.4	222	44
17	.....	.....	.....	.....	.....	2,178	7	1.4	152	30
18	.....	.....	.....	.....	.....	2,030	7	1.4	142	28
19	.....	.....	.....	.....	.....	1,881	7	1.4	132	26
20	.....	.....	.....	.....	.....	2,109	7	1.4	148	30
21	.....	.....	.....	.....	.....	2,709	7	1.4	190	38
22	.....	.....	.....	.....	.....	7,742	7	1.4	542	108
23	.....	.....	.....	.....	.....	7,346	7	1.4	514	103
24	.....	.....	.....	.....	.....	2,485	7	1.4	174	35
25	.....	.....	.....	.....	.....	2,257	7	1.4	158	32
26	.....	.....	.....	.....	.....	6,376	7	1.4	446	89
27	.....	.....	.....	.....	.....	3,802	7	1.4	266	53
28	.....	.....	.....	.....	.....	3,326	7	1.4	233	47
29	2,851	20	4	570	114	6,376	17	3.4	1,084	217
30	2,039	20	4	408	82	2,851	15	3.0	428	86
31	1,204	17	3.4	205	41	2,020	15	3.0	302	60
Total	6,094	.....	.....	1,183	237	97,336	.....	.....	11,076	2,213

Day.	September.					October.				
	Water.	Mud.	Solids.	Mud.	Solids.	Water.	Mud.	Solids.	Mud.	Solids.
	Acre-ft	*Per ct.*	*Per ct.*	*Acre-ft*	*Acre-ft*	*Acre-ft*	*Per ct.*	*Per ct.*	*Acre-ft*	*Acre-ft*
1	1,683	17	3.4	286	57	13,860	20	4.0	2,772	554
2	1,683	17	3.4	286	57	1,683	15	3.0	252	50
3	1,465	15	3.0	220	44	1,980	15	3.0	297	59
4	1,386	15	3.0	208	42	23,760	20	4.0	4,752	950
5	1,267	12	2.4	152	30	5,940	20	4.0	1,188	238
6	1,109	10	2.0	111	22	11,880	20	4.0	2,376	475
7	990	5	1.0	50	10	7,920	20	4.0	1,584	317
8	891	4	.8	36	7	3,960	15	3.0	597	119
9	792	1	.2	8	2	1,980	12	2.4	238	48
10	990	5	1.0	50	10	1,624	10	2.0	162	32
11	1,980	15	3.0	297	59	1,465	10	2.0	147	29
12	1,624	15	3.0	244	49	1,386	5	1.0	69	14
13	1,267	12	2.4	152	30	1,267	3	.6	38	8
14	1,267	12	2.4	152	30	1,267	3	.6	38	8
15	792	12	2.4	95	19	1,109	2	.4	22	4
16	594	12	2.4	71	14	1,109	2	.4	22	4
17	634	8	1.6	51	10	1,109	2	.4	22	4
18	634	15	3.0	95	19	1,109	2	.4	22	4
19	1,386	20	4.0	277	55	1,109	2	.4	22	4
20	1,624	20	4.0	225	65	990	2	.4	20	4
21	3,960	20	4.0	792	158	990	2	.4	20	4
22	2,099	20	4.0	420	84	990	2	.4	20	4
23	1,782	20	4.0	356	71	792	2	.4	16	3
24	1,782	20	4.0	356	71	792	2	.4	16	3
25	1,327	17	3.4	226	45	792	2	.4	16	3
26	1,228	17	3.4	209	42	792	2	.4	16	3
27	634	17	3.4	108	22	792	2	.4	16	3
28	1,327	20	4.0	265	53	792	2	.4	16	3
29	4,356	20	4.0	871	174	1,782	15	3.0	267	53
30	5,702	20	4.0	1,140	228	990	10	2.0	99	20
31	.....	.....	.....	.....	.....	792	5	1.0	40	8
Total	48,317	.....	.....	7,809	1,579	96,966	.....	.....	15,182	3,032

Discharge of sediment of Gila River at the Buttes for 1895—Continued.

Day.	November.					December.				
	Water.	Mud.	Solids.	Mud.	Solids.	Water.	Mud.	Solids.	Mud.	Solids.
	Acre-ft	*Per ct.*	*Per ct.*	*Acre-ft*	*Acre-ft*	*Acre-ft.*	*Per ct.*	*Per ct.*	*Acre-ft*	*Acre-ft*
1	792	5	1.0	40	8	2,277	2	0.4	46	9
2	792	3	.6	24	5	2,020	2	.4	40	8
3	792	3	.6	24	5	1,822	2	.4	36	7
4	1,980	5	1.0	99	20	1,822	2	.4	36	7
5	1,822	5	1.0	91	18	1,822	2	.4	36	7
6	1,822	3	.6	55	11	1,822	2	.4	36	7
7	1,228	3	.6	37	7	1,663	1	.2	17	3
8	1,228	3	.6	37	7	1,663	1	.2	17	3
9	1,228	2	.4	25	5	1,663	1	.2	17	3
10	1,109	2	.4	22	4	1,525	1	.2	15	3
11	1,109	2	.4	22	4	1,527	1	.2	15	3
12	1,822	3	.6	55	11	1,471	1	.2	15	3
13	1,980	3	.6	59	12	1,471	0	.0	0	0
14	1,822	2	.4	36	7	1,471	0	.0	0	0
15	1,228	2	.4	25	5	1,416	0	.0	0	0
16	990	0	.0	0	0	1,416	0	.0	0	0
17	792	0	.0	0	0	1,416	0	.0	0	0
18	792	0	.0	0	0	1,360	1	.2	14	3
19	634	0	.0	0	0	1,360	1	.2	14	3
20	634	0	.0	0	0	1,360	1	.2	14	3
21	634	0	.0	0	0	1,305	0	.0	0	0
22	594	3	.6	18	4	1,249	0	.0	0	0
23	2,277	5	1.0	114	23	1,360	0	.0	.0	0
24	14,850	5	1.0	743	149	1,471	2	.4	29	6
25	4,752	5	1.0	238	148	1,360	2	.4	27	4
26	4,752	3	.6	143	28	1,305	1	.2	13	3
27	4,158	3	.6	125	25	1,249	1	.2	12	2
28	3,366	3	.6	101	20	1,192	1	.2	12	2
29	2,970	3	.6	89	18	1,137	0	.0	0	0
30	2,574	2	.4	51	10	1,081	0	.0	0	0
31	.....	.....	.....	.....	.....	1,026	0	.0	0	0
Total	65,633	.....	.....	2,273	554	46,177	.....	.....	461	89

Beginning on January 1, 1899, and continuing until July 31, 1899, silt observations were again maintained at the Buttes, the amount of mud and silt being determined as was done in 1895. The results are shown in the following table. This differs slightly in construction from the previous table, but gives results which correspond with it. Column No. 2 gives the daily discharge of the river in second-feet, column No. 3 the per cent of solids, and column No. 4 the solids in second-feet. From the mean monthly discharge in second-feet of water and of solids, the acre-feet of each for each month is determined, as indicated. The total amount of water discharged during the first seven months of 1899 was 118,981 acre-feet, and the amount of solids determined was 1,893 acre-feet, or 1.6 per cent of solids or 8 per cent of mud.

Adding the total number of acre-feet of water during the period of silt observations in 1895 to the acre-feet of water discharged in 1899 gives 479,504 acre-feet of water and a total amount of solids during the entire period of 9,597 acre-feet. From these figures an average of 2 per cent of solids for the entire period of observation is determined. It will be noted that the observations in 1895 began on July 29 and extended to December 31, while the observations of 1899 began January 1 and extended to July 31, inclusive, making one complete year and three days. The total mean annual discharge of water of Gila

Discharge of sediment of Gila River at the Buttes for 1899.

[Observer, C. W. Lemon.]

Day.	January.			February.			March.		
	Water.	Solids.	Solids.	Water.	Solids.	Solids.	Water.	Solids.	Solids.
	Sec.-ft.	*Per ct.*	*Sec.-ft.*	*Sec.-ft.*	*Per ct.*	*Sec.-ft.*	*Sec.-ft.*	*Per ct.*	*Sec.-ft.*
.....	320	1.0	0.64	170	0.1	0.03	125	0.1	0.02
.....	345	1.0	.69	200	.1	.04	155	.1	.03
.....	370	1.0	.74	550	.3	.33	155	.1	.03
.....	255	1.0	.51	455	.3	.29	110	.1	.02
.....	300	1.0	.60	345	.2	.16	110	.1	.02
.....	275	1.0	.55	410	.2	.16	110	.1	.02
.....	255	1.0	.51	235	.1	.05	155	.1	.03
.....	275	1.0	.55	235	.2	.09	155	.1	.03
.....	255	1.0	.51	200	.1	.04	110	.1	.02
.....	235	1.0	.47	300	.1	.06	140	.1	.03
.....	275	1.0	.55	255	.1	.05	140	.1	.03
.....	480	1.0	.96	300	.1	.06	140	.1	.03
.....	800	1.0	1.60	275	.1	.05	140	.1	.03
.....	500	1.0	1.00	275	.5	.27	100	.1	.02
.....	435	1.0	.87	275	.8	.44	100	.1	.02
.....	390	1.0	.78	255	.4	.20	100	.1	.02
.....	345	1.0	.69	170	.4	.14	110	.1	.02
.....	345	1.0	.69	170	.4	.14	155	.1	.03
.....	320	1.0	.64	140	.4	.11	155	.1	.03
.....	275	.3	.16	170	.3	.10	155	.1	.03
.....	255	.2	.10	170	.3	.10	155	.1	.03
.....	235	.2	.09	170	.3	.10	140	.1	.03
.....	320	.3	.19	155	.3	.09	140	.1	.03
.....	370	.2	.15	200	.3	.12	140	.1	.03
.....	255	.2	.10	155	.2	.06	140	.1	.03
.....	300	.2	.12	155	.2	.06	140	.1	.03
.....	235	.3	.14	170	.2	.07	125	.1	.02
.....	255	.3	.15	125	.2	.05	110	.1	.02
.....	235	.3	.14	.....	.....	.....	125	.1	.02
.....	170	.1	.03	.....	.....	.....	110	.1	.02
.....	185	.1	.04	.....	.....	.....	100	.1	.02
Mean, sec.-feet	318		.48	239		.12	130.5		.12
Acre-feet	19,552		30	13,273		7	7,993		1.0

Day.	April.			May.			June.			July.		
	Water.	Solids.	Solids.	Water.	Solids.	Solids.	Water.	Solids.	Solids.	Water.	Solids.	Solids.
	Sec.-ft.	*P. ct.*	*S.-ft.*	*Sec.-ft.*	*P. ct.*	*Sec.-ft.*	*Sec.-ft.*	*P. ct.*	*Sec.-ft.*	*Sec.-ft.*	*P. ct.*	*Sec.-ft.*
.....	90	T.	0.01	38	T.	0	5	T.	0	5	T.	0
.....	90	T.	.01	34	T.	0	36	T.	0	5	T.	0
.....	90	T.	.01	30	T.	0	26	T.	0	5	T.	0
.....	100	T.	.01	30	T.	0	16	T.	0	3	T.	0
.....	100	T.	.01	31	T.	0	12	T.	0	3	T.	0
.....	100	T.	.01	28	T.	0	11	T.	0	3	T.	0
.....	80	T.	.01	26	T.	0	16	T.	0	2	T.	0
.....	70	T.	.01	25	T.	0	6	T.	0	2	T.	0
.....	60	T.	.01	24	T.	0	5	T.	0	2	T.	0
.....	60	T.	.01	24	T.	0	5	T.	0	2	T.	0
.....	50	T.	.01	24	T.	0	4	T.	0	300	27	16.20
.....	70	T.	.01	23	T.	0	4	T.	0	320	26	16.64
.....	70	T.	.01	23	T.	0	2	T.	0	250	20	10.00
.....	70	T.	.01	20	T.	0	2	T.	0	130	20	5.20
.....	60	T.	.01	16	T.	0	2	T.	0	90	18	3.24
.....	60	T.	.01	14	T.	0	2	T.	0	170	12	4.08
.....	60	T.	.01	12	T.	0	1	T.	0	250	24	12.00
.....	60	T.	.01	13	T.	0	1	T.	0	920	10	18.40
.....	60	T.	.01	13	T.	0	1	T.	0	1,800	22	79.20
.....	50	T.	.01	14	T.	0	1	T.	0	8,700	14	243.60
.....	60	T.	.01	12	T.	0	1	T.	0	4,100	10	82.00
.....	50	T.	.01	10	T.	0	1	T.	0	2,260	14	63.28
.....	50	T.	.01	8	T.	0	1	T.	0	1,900	15	57.00
.....	60	T.	.01	9	T.	0	1	T.	0	1,550	10	31.00
.....	50	T.	.01	11	T.	0	1	T.	0	1,445	10	28.90
.....	40	T.	.01	12	T.	0	2	T.	0	1,550	8	24.80
.....	20	T.	.01	13	T.	0	2	T.	0	1,550	7	21.70
.....	30	T.	.01	10	T.	0	1	T.	0	3,640	10	72.80
.....	30	T.	.01	9	T.	0	1	T.	0	2,440	15	73.20
.....	30	T.	.01	6	T.	0	.....	.....	.....	2,475	10	49.50
.....	.....	.....	.....	4	T.	0	.....	.....	.....	990	12	23.76
Mean, sec.-ft.	62.3		.01	18.2		0	5.4		0	1,188.2		30.21
Acre-feet	3,689		1.0	1,107		0	30.7		0	73,060		1,854

T.—Trace.

River at the Buttes has been determined as 469,093 acre-feet. If 2 per cent of this volume be considered as solids, it will indicate an annual discharge of solids of 9,382 acre-feet, which corresponds very closely with the 9,597 acre-feet determined in the twelve months during which observations occurred.

The capacity of the Buttes reservoir, with the dam 150 feet high to the spillway, is 174,040 acre-feet. If 9,711 acre-feet of solid matter is delivered to the reservoir each month, and it all settles in passing through the basin, this reservoir would fill with solid matter in eighteen and six-tenths years. The mean annual flow of water of Gila River at San Carlos has been determined as 422,184 acre-feet. If 2 per cent of this volume is solids, there would be delivered to the reservoir 8,443 acre-feet of solids per annum. The capacity of the San Carlos reservoir, with the dam as planned, 130 feet high to the spillway, is 241,396 acre-feet. If 8,443 acre-feet of solid matter should be delivered to this reservoir each year and should be deposited therein, it would fill in twenty-eight and five-tenths years.

These figures show the exceeding gravity of the silt proposition on Gila River. No other stream is known in America which carries such large volumes of débris. It is evident that some provision must be made to avoid the destruction of the reservoir or the building of the dam would be useless. It would be cruel to develop a civilization upon irrigation which would have to be destroyed at the end of a generation. It is extremely fortunate that there is more than one reservoir site on Gila River the water from which would be available for irrigation in the neighborhood of the Gila River Indian Reservation. If a dam should be constructed at San Carlos and the reservoir become filled with silt, it would be possible to construct at the end of the twenty-eight and five-tenths years a second dam at Riverside of equal capacity, and after that reservoir became filled with silt the dam at the Buttes could be built. A fourth reservoir site of considerable value may be found at Guthrie, above the Solomonville Valley, on the same stream, and of large capacity. In the case of all these dams the capacity increases very rapidly with an increased height of dam. For instance, if the Buttes dam should be raised 10 feet above the 150-foot contour, its capacity would be increased 33,755 acre-feet; and if raised 20 feet, its capacity would be increased 72,355 acre-feet. If the San Carlos dam should be increased in height 20 feet, its storage capacity would be increased 135,780 acre-feet. It would therefore be possible to very greatly increase the storage capacity of these reservoirs by building the dams to greater heights as the basin filled with mud. The spillways of the San Carlos dam, as planned, could be raised 1.24 feet in height, increasing the capacity of the reservoir to that extent at small cost, without endangering the structure.

The silt which is carried by Gila River is exceedingly light and requires a number of days to settle in a test tube, and it is believed that

a portion of it will remain in suspension until it is carried over the spillway or through the gates. As irrigation is practiced on the flat lands of the Gila Valley the water plane in that district will be raised much nearer to the surface than it is now, and less irrigation will be necessary. Numerous points are known in the San Joaquin Valley, in California, where water could not be obtained in wells prior to irrigation, and where now, after twenty years of irrigation, water is standing at the surface. Near Fresno, California, the water plane has risen to such an extent that but one irrigation a year is needed on the vineyards.

When the irrigation country has developed to the extent that all water available from the reservoir is required, and when the reservoir has reached the point where the silting endangers the community, it probably will be advisable to construct a large storm channel around the margin of the reservoir and above the maximum water line to carry as much as possible of the water of the river. Such portion of the water as is needed for irrigation below can be passed through this canal without stopping in the reservoir and may be diverted at the proper point near the irrigated fields. This canal could be constructed of large section for the first portion of its course and the section afterwards reduced. A spillway should be located at the point where the canal is reduced in capacity and the excessive water be drawn from the top of the canal into the reservoir. A larger portion of the sediment which would travel in the bottom of the channel would remain in the conduit, and the clarified water would be discharged into the reservoir. A velocity may be maintained in the remaining portion of the canal sufficient to carry the silt through it to the river below the dam.

The suggested canal, being above the maximum water line, would provide an effective head for hydraulic giants for sluicing the silt which had previously been deposited in the reservoir. On favorable occasions, when the reservoir was practically empty, this sluicing or washing out of the basin could be practiced. On July 11, 1899, there was 27 per cent of mud in Gila River at the Buttes. This is the greatest amount of sediment ever observed in this river. From this it will be seen that the suspended matter is exceedingly light, and it would therefore be possible to move large quantities of this loose mud with hydraulic giants and carry it in temporary flumes, or even in the river channel itself, through openings in the dam. Experience with light silt in constructed reservoirs elsewhere shows the greatest deposits to occur where the water is deepest, which is near the dam. Here is also the greatest storage capacity of the basin.

The drop from the storm canal to the bed of the river below the dam would probably be not less than 150 feet. If 500 cubic feet of water per second should be discharged through this canal, over 8,475 theoretical horsepower could be developed. During certain periods

of the year Gila River is almost dry, and this power would not be available from the canal; but when such occasions existed in the river the reservoir would necessarily be drawn upon for irrigation, and power could be obtained from the discharge from the reservoir. It is possible that from 2,000 to 5,000 horsepower could be developed in this manner. The section of Arizona in the neighborhood of San Carlos is highly mineralized. Copper mines of great value are to be found at Globe and at Riverside. New and effective processes have been discovered for reducing copper matte electrically. Fuel is high priced. On the above basis it is reasonable to presume that when the time arrives for the building of the storm canal around the reservoir sufficient revenue can be obtained from power to pay the interest on the cost of construction of the storm ditch. This power could also be used in cleaning out the reservoir with hydraulic dredges.

While the deposit of silt in the reservoir is probably the most serious question in connection with the impounding of water on the Gila, it is believed, on the basis of the above arguments, that the situation could be controlled and that the reservoir may be made to do service through a long period of years, if not indefinitely.

EXPLORATIONS FOR BED ROCK AT THE BUTTES.

The material that covers the bed rock at the Buttes and at Queen Creek is a sand and gravel saturated with water in the bed of a canyon, through which varying volumes of water might be expected to be discharged, ranging from 100 cubic feet per second to 1,000 cubic feet per second during the periods of low water on the river. These low stages of the river might be expected to exist from the 1st of April to the 1st of July, after which violent floods of much greater volume would probably occur at the Buttes dam site.

On Queen Creek large bowlders occur at the surface, and although the stream might be expected to be entirely dry during corresponding dates, after that time violent floods might occur any day. Great reticence was felt on the part of everyone in giving figures that should be regarded as even roughly approximate for this work. Numerous well drillers were interviewed in San Francisco and in southern California, and none cared to bid, under the conditions. Two methods of going to bed rock were suggested—one by means of open shafts, and the other by the use of the diamond core drill. Only one bid was received in reply to proposals, and that at the rate of $15 per linear foot. This was rejected as too high. It was admitted by all that the diamond core drill would work accurately and easily in solid rock, but when it came to going through bowlders of varying size it was conceded to be exceedingly difficult, if not wholly impracticable.

As stated above, the one bid was rejected, and the Geological Survey carried on this work at the points in question, and succeeded in thoroughly solving the problem, largely owing to the experience which *Mr. Arthur P.* Davis had acquired in work in Nicaragua.

A DIAMOND-CORE DRILL PARTY AT WORK.

B. BUTTES RESERVOIR SITE.

DIAMOND CORE DRILL.

As this work was somewhat unique, it will be of interest to give its progress in detail, together with a description of the tools employed. In considering the matter of going down with a shaft the most serious problems would be the water encountered. In working with a shaft the river would have to be carried in a flume by the works for a long distance. A large pump would have to be kept going constantly in the shaft, and it is doubtful if under the most favorable conditions it would be able to handle the amount of water which would be encountered. Pumps with valves would be barred on account of the large amount of sand suspended in the water. It was estimated that it would cost $46 per vertical foot to sink shafts under these conditions. This would permit of putting down about four holes at the Buttes with the funds available, with bed rock at from 75 to 123 feet. The actual cost of sinking 170 linear feet of shaft at the mouths of one of the canyons of a southern California river, in an attempt to determine bed rock, was $35.87 per foot, the depths in this case varying from 15 to 30 feet, and the material through which the shafts were sunk consisting of sand and bowlders. This included the labor of building 700 feet of flume, but not the cost of the lumber, which was furnished by the company for all work. There was pumped from these shafts with a 100-horsepower boiler and engines over 100,000 gallons per hour, and yet the water could not be kept down, and the deepest shaft had finally to be abandoned before bed rock was reached.

The best estimate that could be obtained of the cost of sinking by means of the diamond core drills, as furnished by San Francisco contractors, was $12.69 per linear foot, 400 feet to be sunk, but they would not offer a bid even on these figures.

The following letter from Mr. T. F. Richardson, department engineer, dam and aqueduct department, metropolitan water board, of Boston, is of interest as bearing on this subject:

We had two diamond drills, one manufactured by the M. C. Bullock Manufacturing Company, of Chicago, called the Badger drill. This drill was intended for prospecting in tunnels, but was fitted up especially for us for surface work. This machine cost us $900, which included one set of diamonds worth about $200, and the necessary fittings to put down a 1⅝-inch hole about 200 feet.

Our second machine was bought from the Sullivan Machinery Company, of Claremont, New Hampshire, and was called "S-510." This cost was $1,132.80, but no diamonds were included. The two machines were fitted for and were capable of doing about the same amount of work, but the net cost of the Sullivan machine was over $400 more than that of the Bullock machine.

Our work here was very difficult, as the bottom of our gorge was blocked up with large bowlders, and we found it necessary to use several sizes of bits, namely, $\frac{15}{16}$-inch, 1⅜-inch, 1⅝-inch. We also had to fit up so as to be able to put down 1½-inch casing, using diamond bits to bore it down, the purpose of the casing being to bore through bowlders and gravel, so as to be able to work a $\frac{15}{16}$-inch bit inside of it. Altogether we had two quite complete outfits for doing all kinds of work up to 1⅝-inch bits.

The repairs necessary to the machines were not very large, the principal cost of repairs being for new bit blanks and for core lifters; but in order to do the work successfully it is necessary to have quite a number of appliances outside of the actual machines, and these cost considerable money. Our total outlay for machines was $2,625. In addition to this we spent $3,873 for diamonds, but we have at the present time about $700 worth of diamonds on hand, leaving the net cost of the diamonds about $3,173.

When we started in on our diamond-drill work the cost of diamonds was $19 per carat: but at the time we finished the cost of diamonds had risen to $36 per carat, and I believe the price is about $36 at the present time (August, 1898).

The total amount which we drilled was 2,814 feet, the deepest hole being 286 feet deep, and the average depths of holes about 60 feet. The amount accomplished per day was from 0 to 32 feet, the average amount being probably about 10 or 12 feet per day.

The cost of drilling varies very largely, both with the hardness of the rock and the condition of the rock as to being seamy.

Following is the cost of labor, diamonds, and coal for drilling, principally with 1⅝-inch bits, through three different kinds of rock:

Drilling 324.2 feet of rather hard, tough diorite rock:

Labor	$341.25
Diamonds	74.30
Coal	17.50
Total	433.05
Cost per foot	1.34

(86.6 feet of this was drilled with 1⅝-inch bit, and 237.6 feet was drilled with 1¾-inch bit.)

Drilling 150.7 feet of very hard syenite rock:

Labor	158.00
Diamonds	298.69
Coal	10.50
Total	467.19
Cost per foot	3.10

(Size of drill, 1¾ inches.)

Drilling 286.1 feet of soft schist rock:

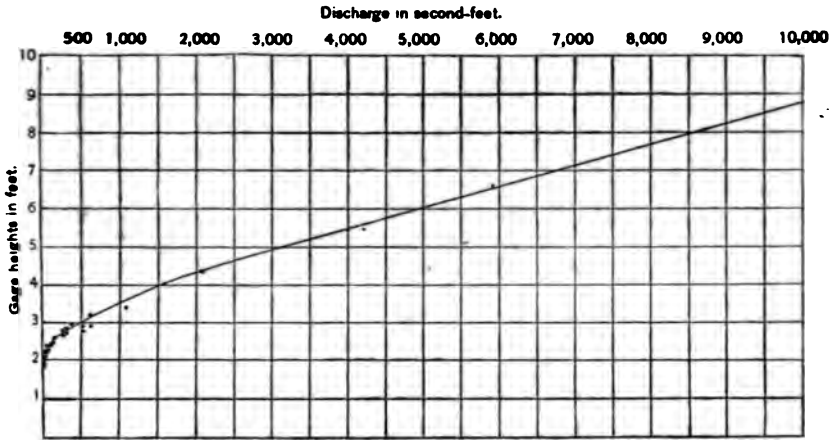
Labor	190.00
Diamonds	87.75
Coal	11.50
Total	289.25
Cost per foot	1.01

(Size of drill, 1¾ inches.)

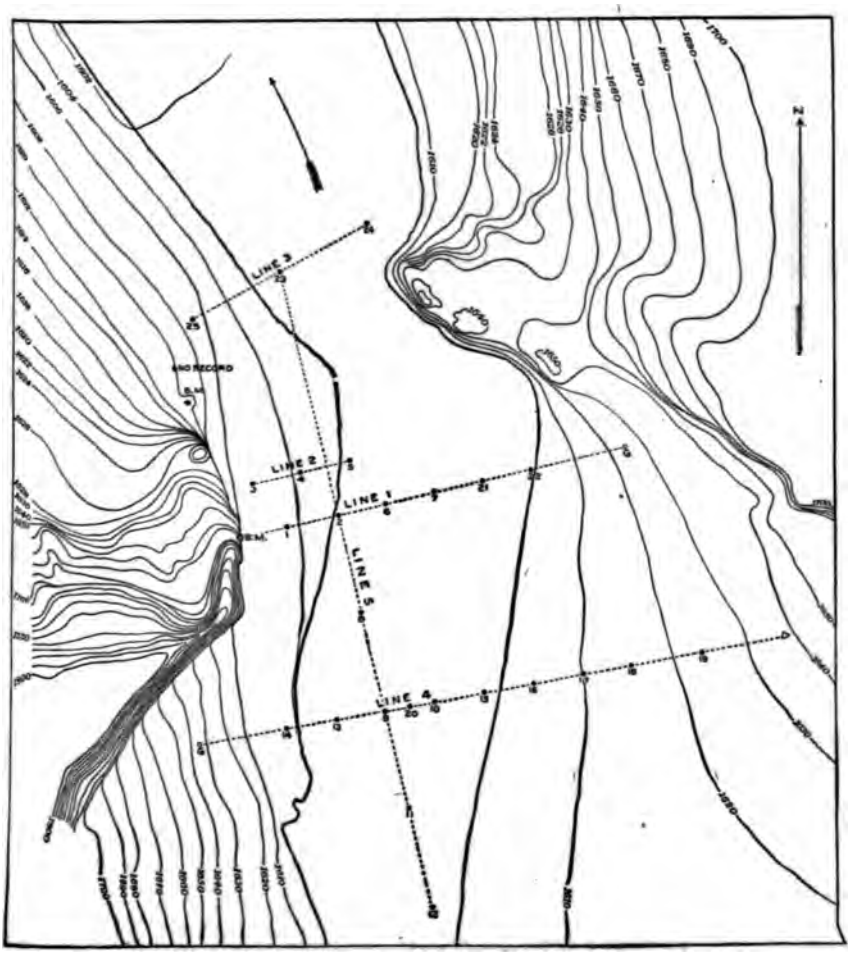
You will notice that there is a large variation in the cost of drilling through different kinds of rock. The costs as given do not include more or less lost time, and the depreciation on diamonds due to their being of smaller size after being used. Finally they get so small as to be valueless. Depreciation of plant is also not included.

Regarding the best size of hole for prospecting purposes, this depends largely on the work which you have in hand. If I were fitting up for similar work to what we did here, and only expected to fit up one size of hole, I should fit up probably for 1⅝-inch bit.

When I speak of 1⅝-inch bits, I mean bits that give cores of about this size, *though generally* the cores are somewhat smaller than the sizes noted.



A. RATING CURVE FOR GILA RIVER AT THE BUTTES. USED DURING PERIOD FROM JULY 11 TO AUGUST 10, 1899.



B. LOCATION OF BORINGS AT BUTTES DAM SITE.

Diamond-drill work is expensive amusement at the best, and I think you will be safe to conclude, whether you do the work yourself, buying the machines, or do it by contract, that the cost will be somewhere in the neighborhood of three or four dollars per running foot.

It was decided to attempt to explore for bed rock by means of diamond core drills, and, through Mr. Arthur P. Davis, who was in charge of the work, machines for this purpose were obtained from the Nicaragua Canal Commission. These machines had been used in Nicaragua in exploring for bed rock along the route of the proposed canal, and had done efficient service. Two foremen, Mr. P. Tierney and Mr. T. J. H. Archambault, were employed to run the machines. These men had previously used them in Nicaragua, and were entirely competent to do the work efficiently. The machinery is in two distinct parts: First, a pile-driving apparatus for putting pipe or casing down through quicksand or earth; the pipe is afterwards washed out, and inside of it the shaft with the diamond bits is operated. The second part is the drilling apparatus proper. The machinery is very light, and made so that it can be knocked down to weights that will admit of the sections being carried on the backs of men. The hammer is in sections and can be increased or lessened in weight. The bottom section is cored out and filled with wood, so that the blow of the hammer will not abrade the head of the pipe. It is raised by means of a hand winding drum, and is tripped when it reaches the tops of the guides, and falls upon the pipe. The maximum lift is 11½ feet and the maximum weight 190 pounds. A tool-steel head is screwed into the top of the drive pipe for the hammer to fall upon.

The pipe is shod at its lower end with a tool-steel shoe, which is thicker and heavier than the pipe, but equal to it in interior diameter. The size of the pipe used is 3½-inch, 2½-inch, and 2-inch extra heavy screw pipe, with extra heavy couplings which have beveled corners. The smaller diameter pipe is in each case made to fit into the larger diameter if required. It, however, requires a special make of 2½-inch pipe to go inside of the 3½-inch pipe. The pipe is driven through the sand and gravel until bed rock is reached. This is indicated by the refusal of the pipe to go any farther under driving. The pipe is cut in 5-foot sections, and as it is driven into the ground new sections are put on until the desired length is reached. When the drive pipe has reached bed rock, what is known as a chopping bit, which is a bit with openings for water to flow through its point, and to which is screwed a ¾-inch pipe, is worked into the drive pipe. The top of this ¾-inch pipe is connected with a small, double-action hand force pump by a hose.

The chopping bit is churned around in the sand which is inside of the drive pipe, and the water which is under pressure is discharged through the point of the chopping bit, and floats the loosened sand out over the top of the drive pipe. In this manner a hole can be readily cleaned to depths *as great as 130* feet of sand and small gravel.

The diamond-drilling machinery is put to work when the drive pipe is cleaned out, and it is possible that it may demonstrate that, instead of being on bed rock, the drive pipe has stopped upon a bowlder. As soon as the diamond bit passes through a bowlder it drops, which is an indication that bed rock has not been reached. The diamond drill is then drawn and four or five sticks of giant powder are lowered through the pipe to the bowlder. The drive pipe is then pulled up four or five feet, and the powder discharged by means of an electric firing battery. This shatters the rock, and the drive pipe may then be forced through the splintered bowlder. In this manner pipe of these varying diameters were driven to bed rock at five different dam sites, and at every location successful results were obtained.

COST OF OPERATING.

The diamond-drilling machine used was built by the American Diamond Rock Drill Company, of 123 Liberty street, New York. One-inch bits were usually employed. The diamond drilling machinery is shown on Pls. I and VII, *A*. The drill is operated by hand power, six men being economically employed on this work, as well as on the driving of the pipe. The machine is capable of going 200 feet into the rock, and will make from 6 to 8 feet a day in hard rock, and from 10 to 15 feet a day in softer rock. The cost of the machinery complete is approximately $1,000, including two bits, which are worth about $200 each, set with six diamonds each. The diamonds are known as black diamonds, and should weigh approximately 1 carat each. Two machines were used on work in southern Arizona. There was paid for the pipe $590, including tools and fittings, delivered in Arizona; $100 of this amount being freight from New York. This would make a total cost of outfit complete of $1,590.

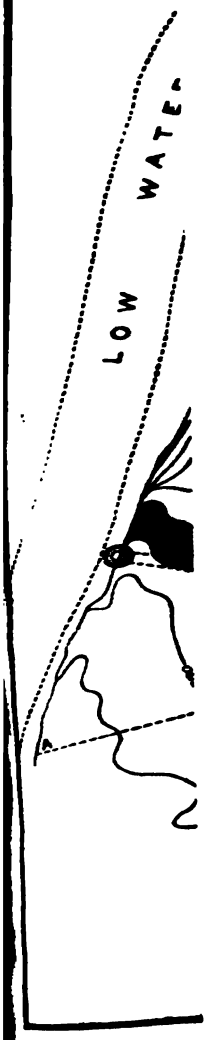
Cost of operation per month of bed-rock exploration.

Foreman	$150.00	
6 laborers, at $1.50 per day, 28 days	234.00	
1 cook	45.00	
		$429.00
240 rations, at 60 cents		144.00
Total repairs, pipe and lumber for one party for ten months	500.00	
Total commissary charges for team, feed, etc	350.00	
Total moving	670.00	
Total sundry incidentals	200.00	
Total supervision	350.00	
Total, ten months	2,070.00	
Sundry expenses per month		230.00
Total cost per month		803.00
Ten months, at $803		8,030.00
Total number of feet sunk		3,254.2
Total cost		$8,030.00
Cost per foot		2.46
Cost per hole, 7,227÷52		154.42

HYDE FORBES

GEOLOGIST & HYDROGRAPHIC ENGINEER.

U. S. GEOLOGICAL S



If the original cost of machinery be distributed over this work, the results would be as follows:

Operation	$8,030.00
Machinery	1,600.00
Total cost	9,630.00

Or average cost per foot, $2.86.

Both machines are still in good repair after having been used in Nicaragua and in various localities in Arizona and California.

The total depths penetrated in all materials at the various dam sites are:

	Covering.	Rock.	Total.
The Buttes	1,621.2	196.0	1,817.2
Queen Creek	357.8	55.6	413.4
Riverside	729.8	40.2	770.0
Dikes	80.0	0.0	80.0
San Carlos	143.2	30.4	173.6
Total	2,932.0	322.2	3,254.2

The work at the Buttes at the last three holes and at the Dikes was very greatly delayed, owing to the loss of the original drive pipe by breaking beneath the surface. The pipe that was next obtained broke continually under the hammer, and a month's time of one party was lost by these interruptions. The expense of this work is included in the above estimate. Owing to the long move by teams of the outfit to San Carlos dam site and the constant interruption by floods of the work at that point and the consequent small amount of driving done there (173.6 feet), the cost of that portion of the work was about $6 per linear foot. If San Carlos is not included in the estimate, the average cost per foot for the remaining portion of the work would be reduced about 10 cents.

The advantages of this class of work over the shaft method are manifest. It is probable that not over five or six shafts could have been put down with the total funds available in case that method was practiced, and it is problematical even then if it could have been accomplished. By the drilling method employed the location of bed rock is not only determined, but an actual sample has been brought up, which can be tested for specific gravity, crushing strength, texture, quality, or in any other manner desired. The work was entirely successful, except at San Carlos, where the floods became so violent during the month of August, 1899, that the machinery could not be kept

standing in the river, and but two holes reached and penetrated the bed rock.

BUTTES RESERVOIR.

EXPLORATION FOR FOUNDATIONS OF DAM.

As recommended in the report by Mr. Arthur P. Davis, made in 1896, explorations have been made to determine the depth of bed rock and the quality of the rock at the Buttes dam site. By this survey of 1899 the diamond core drill demonstrated the fact that the soundings which were made by rods and which are described in the report above mentioned were misleading. There is proved to be a limit beyond which it is impossible to drive rods in gravel and sand, and this limit, which is found to be approximately 60 feet in the material composing the bed of the Gila, prevented the correct determination of bed rock in 1896 by the rod method. Twenty-four holes were put down by the diamond core drill at various points in the canyon at the Buttes, the effort having been made to find some point where the bed rock would be shallow. The following table shows the depth and character of the bed rock determined.

Log of borings at the Buttes dam site, Gila River, Arizona.

Line No.	Hole No.	Depth to bed rock.	Depth to bottom of boring.	Depth drilled in rock.	Correct elevation of surface June, 1899.	Correct elevation of bed rock.	Bed-rock elevations reduced to datum of contour map (= +13.38).
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
3	23	57.0	63.0	6.0	1,589.00	1,532.00	1,545.38
3	24	46.4	53.5	7.1	1,589.00	1,542.60	1,555.98
2	3	21.4	28.3	6.9	1,591.52	1,570.22	1,583.60
2	4	70.0	77.5	7.5	1,589.00	1,519.00	1,532.38
2	5	122.6	132.0	9.4	1,589.00	1,466.40	1,479.78
1	1	65.0	82.0	17.0	1,589.00	1,524.00	1,537.38
1	2	80.0	95.0	15.0	1,589.00	1,509.00	1,522.38
1	6	105.0	112.3	7.3	1,589.00	1,484.00	1,497.38
1	7	70.0	79.0	9.0	1,589.00	1,519.00	1,532.38
1	21	53.0	64.0	11.0	1,589.00	1,536.00	1,549.38
1	22	13.5	20.2	6.7	1,589.00	1,575.50	1,588.88
4	14	8.0	12.6	4.6	1,589.00	1,581.00	1,594.38
4	13	62.1	68.9	6.8	1,589.00	1,526.90	1,540.28
4	9	71.4	78.7	7.3	1,589.00	1,517.60	1,530.98
4	20	68.6	74.5	5.9	1,589.00	1,520.40	1,533.78
4	10	66.8	84.1	17.3	1,589.00	1,522.20	1,535.58
4	15	64.0	70.7	6.7	1,589.00	1,525.00	1,538.38
4	16	62.7	70.7	8.0	1,594.00	1,532.10	1,545.48
4	17	70.0	79.0	9.0	1,596.62	1,526.62	1,540.00
4	18	68.7	79.1	11.4	1,602.12	1,533.42	1,546.80
4	19	26.4	34.0	7.6	1,610.62	1,584.22	1,597.60
5	8	78.0	95.0	17.0	1,589.00	1,511.00	1,524.38
5	11	82.0	94.0	12.0	1,589.00	1,507.00	1,520.38
5	12	(*a*)	----------	----------	----------	----------	----------
	25	(*b*)	----------	----------	----------	----------	----------

a Not reached at 77 feet. *b* Not reached at 101 feet.

The contour maps of the Buttes dam and reservoir sites, which were surveyed in 1896, were based upon a datum which was taken from the local records of the Florence canal. Subsequently a line of levels

A RESULT OF QUARRY TEST AT CLIFF ON RIGHT BANK BELOW BUTTES DAM SITE.

B DAM SITE ON QUEEN CREEK.

run from the railroad station of Casa Grande, on the Southern ific line, to the Buttes dam site, and upon this datum the topo- phic map of the irrigable lands in the vicinity of Florence was le. Upon this corrected datum the canal surveys were made, and ench mark was established at the Buttes dam site. The elevations n on the large contour map of the dam site, which is on a scale of eet to the inch, are based upon the first elevation of Florence canal um, which the subsequent levels show to have been 13.38 feet too h. The elevations given on the plans and sections of the Buttes l correspond to the elevations of the contour maps of the dam and ervoir surveys and do not correspond with corrected elevations. elevations given in the above table are both the corrected ele- ions and the elevations on the same datum as that used for the tour map and plans of dam.

The holes whose surface elevation is given as 1,589 are those bored the immediate bed of the stream. Those of higher elevations rted on the alluvial benches above low-water level on either side.

QUALITY OF BED ROCK.

At each one of these points a core was brought up showing the ality of the bed rock. The following table is a description of the es obtained at the Buttes:

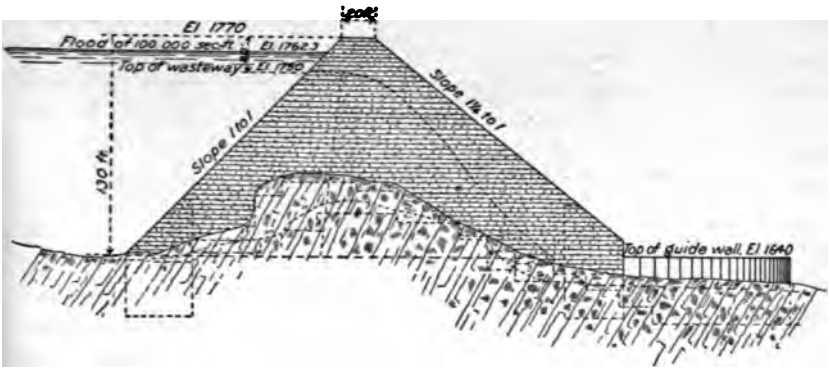
Cores obtained from borings at the Buttes.

Number of hole.	Depth drilled in rock.	Length of core obtained.	Quality of rock.
	Feet.	*Feet.*	
23	6.0	4.00	Pearlite.
24	7.1	4.40	Pearlite and ash.
3	6.9	2.40	Pearlite, very solid and brittle.
4	7.5	1.30	Volcanic ash.
5	9.4	4.25	Volcanic ash, badly pitted.
1	17.0	9.00	Pearlite, mingled with ash.
2	15.0	1.40	Porous ash.
6	7.3	2.40	Volcanic ash, badly pitted.
7	9.0	5.30	Hard ash.
21	11.0	2.40	Hard, volcanic ash.
22	6.7	5.00	Pearlite.
14	4.6	3.00	Volcanic ash.
13	6.8	1.80	Volcanic ash, very porous.
9	7.3	5.20	Blended ash and pearlite.
20	5.9	4.50	Volcanic ash.
10	17.3	4.10	Volcanic ash, quite hard, but badly pitted.
15	6.7	.85	Very porous volcanic ash.
16	8.0	5.00	Volcanic ash.
17	9.0	2.50	Do.
18	11.4	1.66	Do.
19	7.6	4.00	Do.
8	17.0	2.25	Do. very porous.
11	12.0	5.00	Hard, volcanic ash.
12	.....	.....	Bed rock not reached; hard pan at 40 feet.
25	.....	.....	Bed rock not reached.
	216.5	81.71	

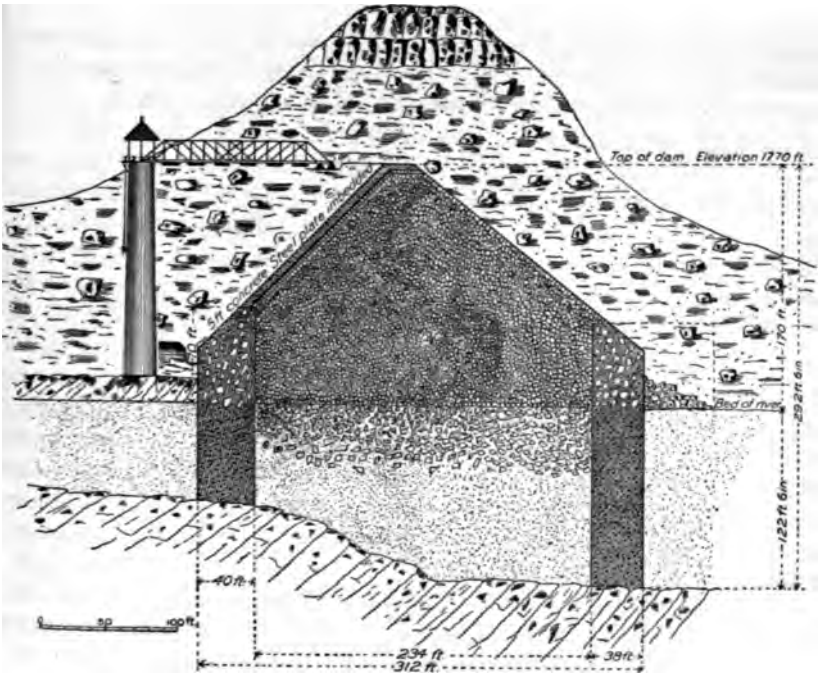
The location of these borings is shown on Pl. VIII, *B*, these being arranged in five different rows. At the relative location of each hole a figure has been placed on the diagram corresponding to the number given in the above tables. The point marked "B. M." shows the position of the bronze bench mark set in the face of the cliff. It is the initial point of the survey for the location of the borings. At the point marked "G" is a steel gad seven-eighths of an inch in diameter, set in the rock.

In taking out many of the cores it was found that, while the drill had entered the rock for distances of from 6 to 12 feet, the cores extracted were very much less in length, owing to the crumbling of the rock as it was cut. The bed rock varies between a volcanic glass, or obsidian called pearlite, and a porous ash. The obsidian is exceedingly hard, but the ashy material is full of holes, quite soft, being readily cut with a knife, and of a crumbling nature. A total depth of 216.5 feet was bored into the bed rock, and but 81.71 feet of core obtained therefrom, or only 38 per cent of the total length of the core was of such material as would permit of its extraction from the holes. It is but fair to assume that the remaining 62 per cent is of a poorer class of material than that which was extracted.

The following table gives crushing tests which were made in the laboratory of the city engineer's office at Los Angeles, California. The crushing limit of the machine used is 2,565 pounds per square inch. This would be equivalent to 184.7 tons per square foot. A good many of the samples could not be crushed on the machine, but it has been considered that all rock which could not be crushed with this pressure is reliable and could be accepted as a satisfactory foundation material. The poorest rock is undoubtedly that portion of the core which has gone to pieces under the action of the diamond drill, and which could not be extracted. Tests were obtained from the samples as low as 79.5 tons per square foot. It may therefore be assumed that the tests made are of the better class of rock, and that if any of the samples indicate a weakness below the limit of safety it would justify the abandonment of the bed rock as a proper foundation for a cement-masonry dam. The assumed maximum height of the dam being 170 feet above the bed of the stream, and 123 feet to bed rock below the same, or a total height of 293 feet, the base would have to be made so wide in order to keep the pressure at the outside toe within safe limits that the cost would be prohibitory. Some of the cores having crushed with 80 tons pressure per square foot, a rubble-masonry dam is abandoned for this site. Crushing tests were made by J. W. Robinette and S. G. Bennett. Specimens were 1 inch long and 1 inch in diameter.



A. ELEVATION OF END WALL OF BUTTES DAM.



B. MAXIMUM CROSS SECTION OF PROPOSED DAM AT THE BUTTES, ARIZONA.

pecific gravity, weight per cubic foot, and crushing tests of diamond-drill core from bed rock at the Buttes, Arizona.

No. of specimen.	Weight in air.	Weight in water.	Loss.	Specific gravity.	Weight per cubic foot.	Crushing test, pounds per cubic inch.	Crushing test, tons per cubic foot.	Remarks.
	Ounces.	*Ounces.*	*Ounces.*					
1	1.10	0.60	0.50	1.86	116.4	2,565+	184.7+	Stood 2,000 pounds.
2	0.75	0.30	0.45	1.66	103.0	1,085	79.5	Crushed at 807 pounds.
3	1.30	0.75	0.55	2.39	149.5	2,565+	184.7+	Stood 2,000 pounds.
4	0.95	0.45	0.50	1.93	120.5	2,565+	184.7+	Do.
5	0.90	0.47	0.43	1.79	112.0	2,565+	184.7+	Do.
6	0.82	0.40	0.42	1.95	122.0	2,469	177.0	Crushed at 1,926 pounds.
7	0.70	0.30	0.40	1.75	109.0	2,288	164.7	Crushed at 1,785 pounds.
8	0.85	0.40	0.45	1.86	116.4	2,565	184.7+	Stood 2,000 pounds, but developed longitudinal crack after being taken out of testing machine.
9	0.90	0.45	0.45	2.0	125.0	2,088	150.0	Crushed at 1,629 pounds.
10	0.95	0.46	0.49	1.855	116.0	2,565+	184.7+	Stood 2,000 pounds.
11	0.86	0.45	0.41	2.10	131.0	2,077	149.5	Crushed at 1,620 pounds.

QUARRY TESTS.

The rock at the Buttes appearing to be of a questionable quality for concrete or rubble masonry work, it was decided to be necessary to make quarry tests in order to determine accurately its nature. Mr. D. Anderson, mason and quarryman, of Los Angeles, California, made the following quarry tests:

At the first cliff on the right bank below the dam site at the Buttes, 12 feet back from the edge, two holes were put down, 5 feet 6 inches and 3 feet in depth, respectively. This location is marked by the figure 1 on contour map of the Buttes dam site (Pl. IX). Eight sticks of giant powder started the rock and one 25-pound keg of black powder pushed it off. The result was one 10-ton rock, one 2-ton rock, and numerous small rocks ranging from 25 to 500 pounds. The rock is a pearlite, heavy, close grained, and fairly free from seams. It dropped from 150 to 175 feet, to the foot of the cliff, falling partly on earth and partly on rock, without badly shattering it. It drills easily, two strikers going 18 inches an hour with 1¼-inch bit, but large quantities of powder are required to start the rock.

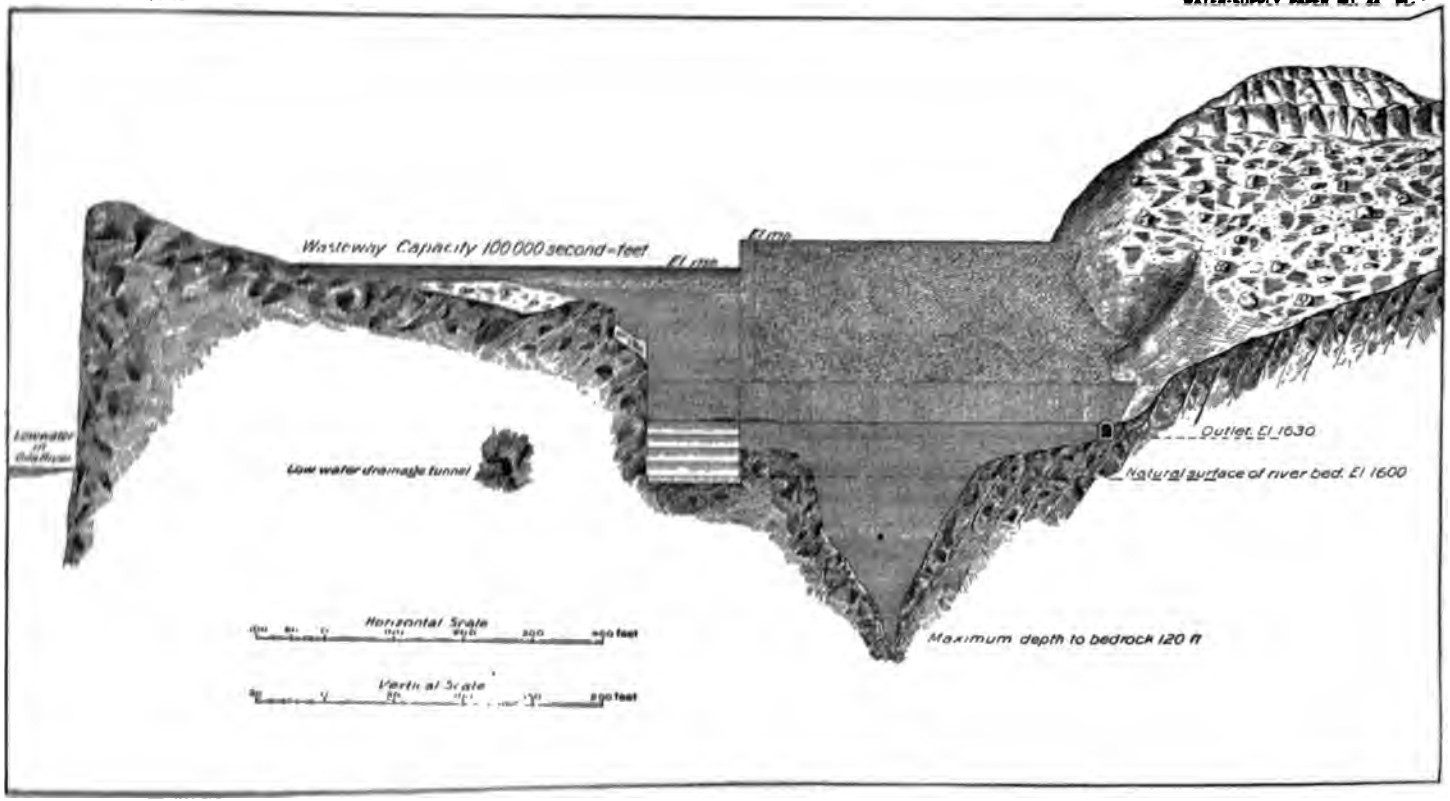
The second test, at figure 2 on Pl. IX, was on east face of same cliff. Five-foot holes were put down in a step series, 2½ sticks of giant powder being used to spring each. Afterwards holes 2½ feet deep were filled with black powder, 3 kegs being used in five holes. The result is hard to estimate—probably 100 to 200 tons of rock were thrown down. There were one 2-ton, two 1-ton, and about twenty quarter-ton rocks. The large pieces are pearlite; the smaller ones are a hard ashy rock.

The point west of the left spillway, at figure 3 on Pl. IX, was opened on June 10, 1899, and a hole was put down 4 feet 4 inches and four sticks of giant powder were exploded therein. The rock exposed seems to be a partly solidified pearlite, light and brittle. Soft streaks and spots are found throughout the mass, and it does not seem suited either in weight or structure to bear a rubble-masonry dam. About one-third of it is a white-colored ash and two-thirds is a gray, hard substance, brittle and light. The ashy material cuts readily with a knife, while the gray is hard to scratch. These white spots are often eroded by wind action when occurring at the surface, holes being thus formed as large as 2 feet in diameter.

At a point 100 feet northeast of the left-hand spillway (bench mark), at figure 4 on Pl. IX, a hole 4 feet 6 inches was put down on June 7 and five sticks of giant powder were used (three and one-half sticks to the pound). The rock is similar to that previously noted, but harder and ashy white, and usually resists a knife, but there are spots that cut like chalk. In the lower portion of the spillway, at figure 5 on Pl. IX, a blast was put off which showed that the material is softer and more fragile in the spillway than elsewhere and of a very questionable nature for cement-masonry work. On the southwest end of the low butte, at the left dam abutment, at figure 6 on Pl. IX, a hole 6 feet deep was put down June 10, and three sticks of giant powder were used to spring it. Twelve pounds of black powder were then used to throw down the rock. This revealed a high-grade, heavy, volcanic glass, resembling the first, tested across the river. Overlying the pearlite is a streak of ashy gray, but harder and darker than at the spillway.

The prevailing rock at the dam site is an indurated ash. It is found in the cliffs of the left bank, east of the spillway and at the proposed upper portal of the tunnel on the right bank. The lighter ash is liable to crush and erode. Probably enough of the pearlite could be selected to build a concrete or rubble dam, but it would be a matter of selection, and much of the lighter rock would have to be moved to get at the better rock. This probably would be 50 per cent of the mass. The rock in the left-hand spillway probably could not be put in a concrete dam. It could, however, be used for a core of a rock-fill dam.

On the first cliff south of the dam site, on the right bank, facing the river, two large blasts were fired at the first projecting point, at figure 7 on Pl. IX. Three holes were put down, 14 feet, 15 feet, and 16 feet deep, 18 feet back from the face of the cliff. The rock was hard and cut coarse. Three men could go down 10 inches per hour with a churn drill. Four pounds of giant powder were used to the hole. This sprung the cliff from one side to the other, about 30 feet deep. The crack was then charged with black powder, 3½ kegs being put down to each hole. The powder in hole No. 2 went into a crevice and did



ELEVATION OF BUTTES DAM LOOKING UPSTREAM.

little good. The entire point sprung, but did not fall, but around the edge was revealed pearlite of a good quality. There were six men in all, including blacksmith and helper, who worked fifty-three hours at this point. The rock dips into the cliff, so that while the ledge was pushed off as much as 5 feet it did not fall.

On June 24 about 50 pounds of giant powder was placed in the key of this mass and shot. This brought it down with the following approximate results: Length of fallen mass, 80 feet; height above sand, 10 feet; depth in sand, 5 feet; width, 30 feet. This is about 440 cubic yards of loose rock. Pl. X, *A*, gives a view of this test. There were approximately one 10-ton rock, ten 5-ton rocks, and thirty 1-ton rocks. The mass ranges from stone that would pass through a 3-inch ring to rocks 150 pounds in weight. It is of a mixed ashy structure, and not solidified glass. There are numerous flow lines or fissures which are contorted, and the rock has gone to pieces badly. This rock fell 180 feet upon the sandy river bed. The pearlite is not so pure as was indicated by the first test; it seems to be stratified, and changes often from pearlite into an ash, or the reverse. Numerous chips knocked off the corners of base of this cliff with a hammer show it to be a hard, volcanic substance, such as is frequently penetrated by the diamond drill as bed rock.

At the west end of the first bluff below dam site on right bank at figure 8 on Pl. X five men worked fifty-three hours. The rock is softer than that at the middle of bluff, shown in last tests. It cuts very easily, but the drill holes clean hard and the dust from cutting forms paste when mixed with water. The average rate of progress with the churn drill is 10 feet an hour. Three holes, 8 feet apart, were put down approximately 16 feet in depth and 18 feet from the face of the cliff. Four pounds of giant powder were used to the hole, and the cliff was cracked across the point. The crack was opened by a second charge, consisting of 2 pounds of giant and 5 pounds of black powder to the hole. This resulted in a crack 2 inches wide, extending 38 feet. There seems to have been an error in judgment on the part of the quarryman in springing the rock too much before using the black powder, which expended its energy, in a large part, through the fissures of the rock. This crack was then charged with ten kegs of black powder, and a portion of the cliff in front of one of the holes was thrown off, knocking down about 300 tons of rock. The other portions on the cliff were not thrown off, but sufficient material was revealed to show the nature of the rock. In this, as in the former case, the rock fell 180 feet. There were from 8 to 10 large rocks displaced, ranging from 6 to 8 tons in weight, but a large portion of the fragments range from 100 to 200 pounds, while much of the rock, possibly 25 per cent, is in pieces weighing less than 50 pounds. There is a large amount of rock buried in the sand. This rock is a reddish or fused ash, rather light and brittle, but hard, and with

many seams. It ranges in a very intricate way from glass to ash, and back again to volcanic glass. Fully 66 per cent is glass. At a point 25 feet south a smaller blast showed pure glassy pearlite, which falls without shattering. The first grade pearlite is rather rare and can not be obtained in large quantities. The ashy material is the prevailing rock and is of inferior grade for construction purposes.

A block of the poorer class of the volcanic ash from the spillway on the left bank, containing soft spots of light, chalk-like material, was immersed in water in June, and continued under water until the first of October, over three months. At the expiration of this time the softer portions of the rock indicated, if anything, a hardening, but still could be cut with a knife. It would be between 2 and 3 in the scale of hardness.

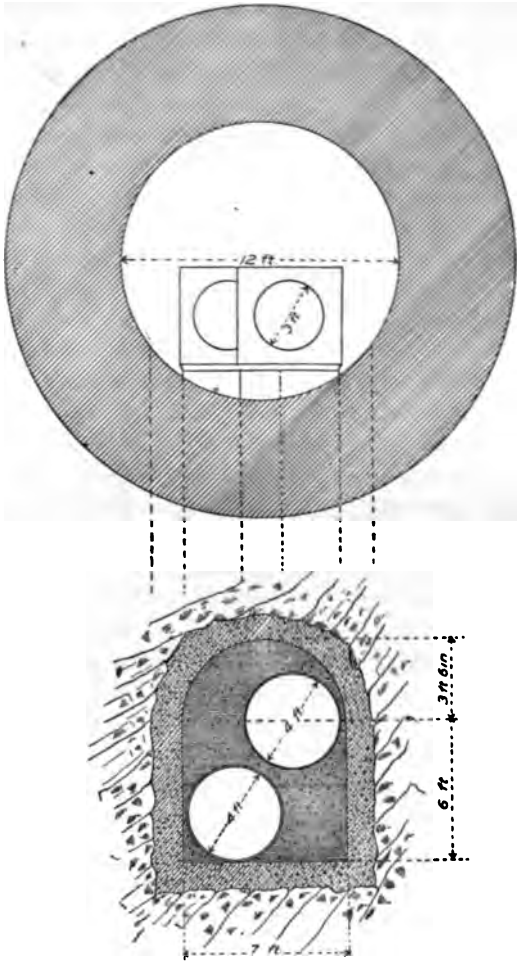
In conclusion, it may be stated that it would be difficult to select a sufficient amount of rock of first-class quality for concrete work or rubble masonry to build a dam of that type of the size required from bed rock to a line 170 feet above the bed of the stream, a total height of 223 feet, without large expense. The rock at the Buttes would be suitable for the construction of a rock-fill dam, the poorer class rock being placed in the center of the dam and selected rock on the two faces and at the spillway weir on the right bank.

It is probable that the dam could be most economically constructed from quarries at the cliffs on the right bank of the canyon below the dam, tramways being used for delivering the rock to the structure. The tramways would vary in length from 500 to 1,000 feet. If cableways were used they could not properly be placed on lines which would be near or parallel to the axis of the dam, and if they were not so located it would require a double system of cables for handling the rock, one to bring it from the quarries to the dam site, and a second set to distribute the rock at the dam.

The conclusion reached from the investigation of bed rock with the diamond core drills and from the quarry tests leads to the adoption of a rock-fill dam for the Buttes as the only class of structure which it would be feasible to build with the material available and on the foundation there existing. For this reason the estimate of cost has been made solely upon this type of dam.

TYPE OF DAM ADOPTED.

It is evident that the desired type of dam must have a very broad base, reducing to a minimum the pressure per square foot on each portion of its foundations. A dam with this breadth of base would call for a heavy expenditure for the excavation to bed rock if the entire section were taken out. In order to be stable and to retain the water impounded above it, the dam must have an impervious connection with bed rock. The style of dam selected (Pl. XI, *B*) is of the rock-fill type, with concrete retaining walls and with a concrete spillway weir



CROSS SECTIONS OF TOWER AND OUTLET TUNNEL OF BUTTES DAM.

on the right side. It is proposed to put a wall down to bed rock at the upper toe of the dam sufficient in thickness to withstand the pressure of water against its upper face when excavations are made behind it. At the lower toe of the dam it is proposed that a similar wall shall be put down to bed rock in order to protect the structure from erosion from the spillway on the right bank and to retain the inclosed mass of sand and gravel as a foundation for the riprap or dry-laid rock.

The section and rear view, looking upstream, of this proposed structure are shown on Pls. XI and XII.

Between these two walls there will be held a mass of sand, gravel, and bowlders, which constitute the natural bed of the river and which will not be excavated. The distance between these two walls is 234 feet. It is proposed that they shall be carried up above the bed of the stream to an elevation of 58 feet on the lower wall and 63 feet on the upper wall. Loose rock will be deposited between them as they are raised in elevation, and the river will be allowed to flow a portion of the time over the masonry walls onto the mass of rubble lying on the sandy bed of the stream. The churning action which will result therefrom will permit the heavy rock to settle into the bed of the river, it being desirable to have this take place as much as possible. In case this does not occur naturally, it is proposed to pump water onto this rock and force a settlement in that manner. The rock forming this portion of the dam will be as large as can be handled.

An outlet tunnel will be constructed through the point of rocks at the right abutment of the dam at the lowest possible elevation, as shown on Pl. XII. This tunnel (Pl. XIV, *A*) will be 15 feet high, 10 feet wide, and 139 square feet in area. It will discharge under pressure and with high velocity and will carry the river at all stages of low water and in ordinary floods. It will be about 1,000 feet in length and have over 1,000 second-feet capacity. This tunnel will permit, during all usual occasions, of the regulation of the river as may be desired during construction. Afterwards it can be used to carry off flood waters, and it will not ordinarily supply water for the irrigation canals. On the left bank the delivery tunnel (see Pl. XII) will be located 30 feet above the natural bed of the stream and will discharge, if desirable, into the main irrigation and power conduit.

A serious problem in connection with the construction of this dam will be the handling of the great floods which possibly may occur in the river during its erection. If such a flood should occur during construction, and be permitted to pass over the dam while it is in an incomplete condition, the loose rocks would probably give way under the violence of the current and destroy the work already performed. There would then be added to the flood the volume of water resulting from the bursting of the reservoir, and disaster would follow not only to the structure itself, but to settlements and towns along the Gila River below the dam. In order to prevent this the

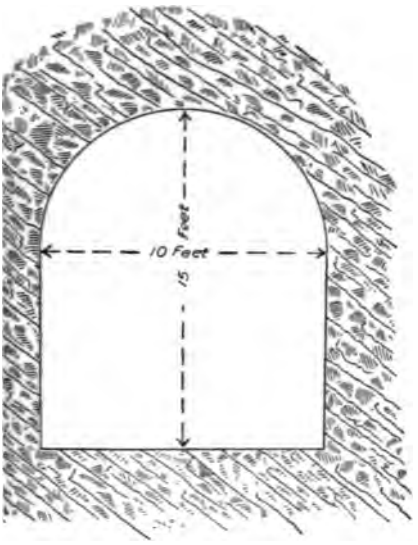
two masonry retaining walls (Pl. XI, *B*) are carried above the bed of the river to the elevations named. If when these walls have reached their maximum height and the intervening space is filled with riprap a flood of great magnitude should pass over the dam the structure would stand, the loose rock being held between the two retaining walls would settle down into the sand bed between them. This would be exactly what would be desired. An examination of Pls. V, *A*, and XII shows that the bed rock has a very flat slope on the right abutment. It is proposed that a wall (Pl. XI, *A*) should be built from this bed rock, as shown on Pl. XII, 20 feet in thickness, as a retaining wall for the right end of the loose-rock portion of the dam, connecting the upper and lower toe walls. The purpose of this wall is to retain the loose rock and to protect it against the attacks of floods. This end wall will be made of concrete, and an excessive thickness will not be necessary, because it will be reenforced by the secondary rubble-masonry weir to its right.

A cut (shown by the crosshatching on Pl. IX) will be made into the sloping rock at the right abutment down to an elevation of 40 feet above the natural surface of the river bed and to a width of 100 feet at the bottom. This cut would be carrying water at a depth of 30 feet when the water reached the elevation of the top of the higher toe wall of the dam, and a corresponding head on the large tunnel of 70 feet would then exist. This would probably carry any ordinary flood which might occur in the river.

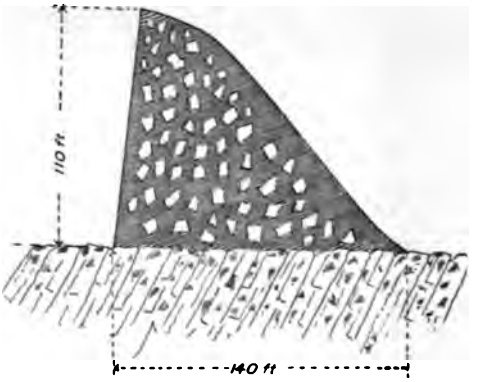
The effort should be made during the first year of construction to complete the two retaining walls from the bed rock to the surface of the stream. During the second season these walls can be completed and as much of the rock-fill dam as possible constructed. In the third year the rock-fill dam should be completed and the concrete weir constructed.

As the work on the rock-fill portion of the dam advances and its crest rises in elevation, the construction of the concrete weir on the right abutment, which is to act as the spillway for the structure, can be begun and carried on with the remaining portion of the work. The two faces of the central dam are to be laid up by hand in dry wall, and the slopes which have been accepted for the dam are practically the natural angles of repose, so that little tendency to slide is likely to exist.

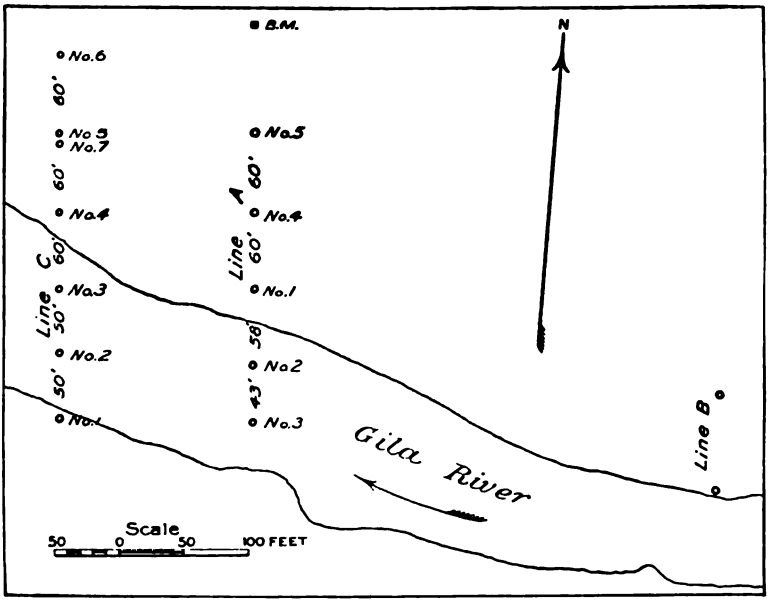
In order to make this structure water-tight it is proposed to cover the upper face with an apron of concrete 5 feet in thickness, which will be connected with the upper toe wall and the two abutments of the dam. In this apron of concrete a continuous riveted steel plate will be embedded 4 feet beneath the water face of the dam and 1 foot from the dry-laid rock wall. Angle irons will be riveted horizontally and vertically on both sides for the purpose of stiffening the plate and insuring a better connection with the concrete. The steel plate



A. CROSS SECTION OF LOW-WATER TUNNEL, BUTTES DAM.



B. MAXIMUM CROSS SECTION OF WASTEWAY, BUTTES DAM.



C. LOCATION OF BORINGS AT RIVERSIDE DAM.

rill make the dam additionally impervious and lend strength to the oncrete.

Gates will be placed at the upper portal of the flood tunnel and will e operated from the surface of the ground. The gates for the tun-el which is to discharge into the irrigation conduit will be operated rom a tower (Pl. XIII)

Quarry tests were made of the spillway on the left bank, and the ock was found to be of such nature that it would not stand the rosion of a great flood. It is of a volcanic, ashy character, porous n spots, light in weight, and portions of it can be readily whittled vith a knife. A flood approaching 100,000 cubic feet per second passing over this material would tear it to pieces, it is believed, and erode great channels. It would be exceedingly expensive to cover his spillway with concrete so as to protect it or to build a series of checks to mitigate the erosive action of the water.

On the right abutment, however, the rock is of a harder nature. It s, to a large extent, an obsidian, or pearlite, and it is believed that it will resist erosion. This bed rock on the right abutment is practically at the surface from an elevation of 20 feet or more above the bed of the stream. A concrete weir of the section shown on Pl. XIV, *B*, will be constructed on this abutment, the elevation of the top being 20 feet lower than the top of the loose rock dam, and of a length of approximately 650 feet. Any flood occurring will pass over this portion of the dam only. This concrete weir will be built into the excavation which was made for the flood waters and connected with the retaining wall at the right end of the rock-fill dam. Its section will be such that any flood may pass over it without injuring it. The dam will be protected on its flank and at its lower toe with solid walls of concrete, and the floods passing over the weir will be discharged away from the main dam into the canyon below.

As a further protection against any churning action of the water which may occur, large blocks of riprap should be laid against the lower toe wall of the dam to prevent the scouring of a large cavity in the bed of the canyon at that point. The lower toe wall should be provided with weep holes, so that hydrostatic pressure against the wall can be avoided. It is believed that the body of sand and gravel between the two toe walls of the dam, which is 234 feet in length and approximately 400 feet in width and which is rigidly sustained by two masonry retaining walls, will be a foundation of a very substantial and satisfactory character for the loose rock embankment composing the dam.

It is a frequent practice in sinking iron caissons for bridge piers to build concrete upon a retained sand foundation of this nature. When the foundations of the retaining walls are uncovered and examined, if the bed rock should prove unsuited to sustain the vertical pressure due to their weight, which will amount to a maximum of 12 tons per

square foot, then the walls will have to be broadened at their base to the proper width to reduce the pressure to the desired limit.

It is believed that a dam could be constructed at the Buttes on the plan outlined that would be a reliable and creditable engineering structure, but the expense would be great, as is shown in the estimate.

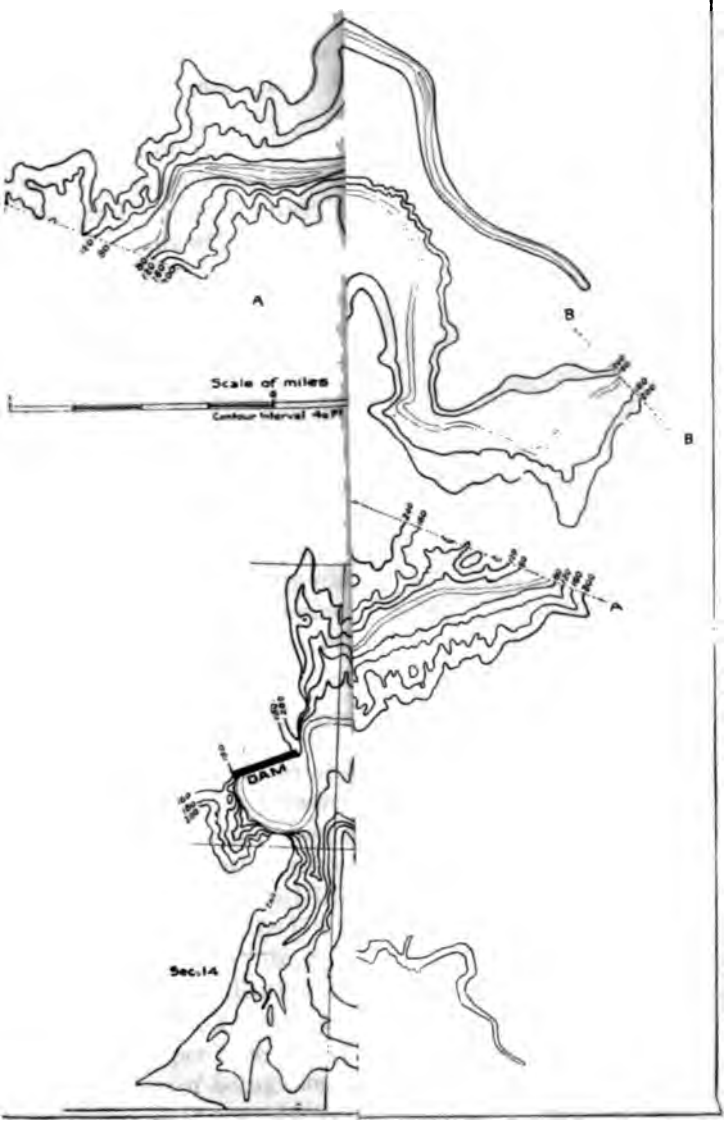
METHOD OF EXCAVATION FOR FOUNDATIONS.

The most serious difficulty in connection with the construction of a dam at the Buttes will be in the excavation for foundations. The plan suggested is the sinking of a series of open caissons. These will be put down as for bridge pier work. They would be weighted on top, and the excavation made probably below water by means of buckets on an endless chain or some similar method. As the excavation in the sand and gravel would progress, the caissons would sink on account of the superimposed weight, and new sections would then be fitted to the top as it went down. The borings with the diamond core drill did not indicate bowlders of large size, and it is believed that these caissons could be put down without serious trouble. The attempt would not be made to keep them pumped out until they reached bed rock, when pumping would be resorted to, the bed rock would be cleaned and examined, and after everything was clear they would be filled with concrete.

A row of these caissons, tangent to each other, would be put down at the upper face of the upper toe wall, and another at the lower face of the upper toe wall, each row being braced against the other. The bed rock where the upper toe wall would be put down is at a maximum depth of 71 feet, and is better than the average bed rock which intervenes between the two retaining walls. At the lower toe wall the bed rock is largely pearlite, and is at a maximum depth of 122.6 feet. The principal trouble in putting down these foundations will be in handling the volume of water to be encountered. Bed rock is nearer the surface at the upper toe than elsewhere. The wall would be naturally put down first here, and this would greatly relieve the volume of water to be handled at the lower toe wall. The two rows of caissons having been placed, the sand and gravel intervening would then be excavated. When the excavation is completed for the upper toe wall between the cylinders, the concrete to constitute the wall would then be placed in solid mass. A similar construction would be followed at the lower toe wall. With the two toe walls completed, the riprap would be placed between them and allowed to sink to the greatest depth possible into the sand.

BUILDING MATERIALS, SAND AND GRAVEL.

A drainage line enters the Gila River at a distance of about 2,000 feet above the dam site, which carries the discharge from an area lying south of the reservoir site. This drainage line for a distance of


A
B
B
Scale of miles
Contour interval 40 ft
A
DAM
Sec. 14

miles varies in width from 100 to 400 feet and is filled to an ›wn depth with a high-grade, coarse building sand, the voids tuting 35 per cent of the mass. This sand would have to be d, and would then be of good quality for concrete. The cement › dam must be shipped, probably, from California to Casa Grande, :ost for railway transportation of $12.20 per 2,000-pound ton. agon haul from the railroad to the Buttes is 40 miles. The amount ıent used should, therefore, be reduced as much as possible. An nation was made for materials from which a natural hydraulic ıt could be made, without successful results. Limestone exists miles below the Buttes dam site, but no good clay was found. ılso would be an expensive element. Coal would have to come New Mexico, if used, and wood from the neighborhood of the ı reservation.

:st, as noted on page 16, was made to determine the possibility .king a silica cement with the Portland cement, which might be ht in, and finely ground pearlite. By mixing one portion of ground cement with an equal bulk of pearlite, so that no residue . remain on a 200-mesh sieve, and adding two parts of coarse not ground, making a mixture of one part finely ground Port- :ement and five parts sand and ground silica, a tensile strength pounds per square inch was obtained at the end of seven days f 300 pounds at the end of twenty-eight days. When the same ıt was mixed with sand on the ratio of 1 to 2, 33 per cent being ı the 200-mesh sieve, a tensile strength of 170 pounds per square vas obtained at the end of seven days and of 385 pounds at the f twenty-eight days. The same pure cement mixed on a ratio of has a tensile strength of 140 and 240 pounds per square inch at ıd of seven and twenty-eight days, respectively. The ground te and finely ground cement mixed on the ratio of 1 to 7 has a e strength of 185 pounds per square inch at the end of twenty- days.

CAPACITY AND COST OF THE BUTTES RESERVOIR.

› basin of this reservoir site, shown on Pl. XV, embraces little ıltural land, and it is estimated that $10,000 will cover all the ges that would be incurred by appropriating it for reservoir pur- . Some copper prospects have been discovered in the reservoir t a point known as the Dikes, but it was subsequent to the filing of this land under the United States laws for reservoir purposes. rther antagonistic interests can become vested here.

› capacity of the Buttes reservoir site is 174,040 acre-feet, and ıtimated cost of constructing this dam is $2,643,327, or an aver- ›st of $15.19 per acre-foot of capacity. The Buttes reservoir site ıe advantage of being closer to the irrigable lands than any other › reservoir sites considered on this river.

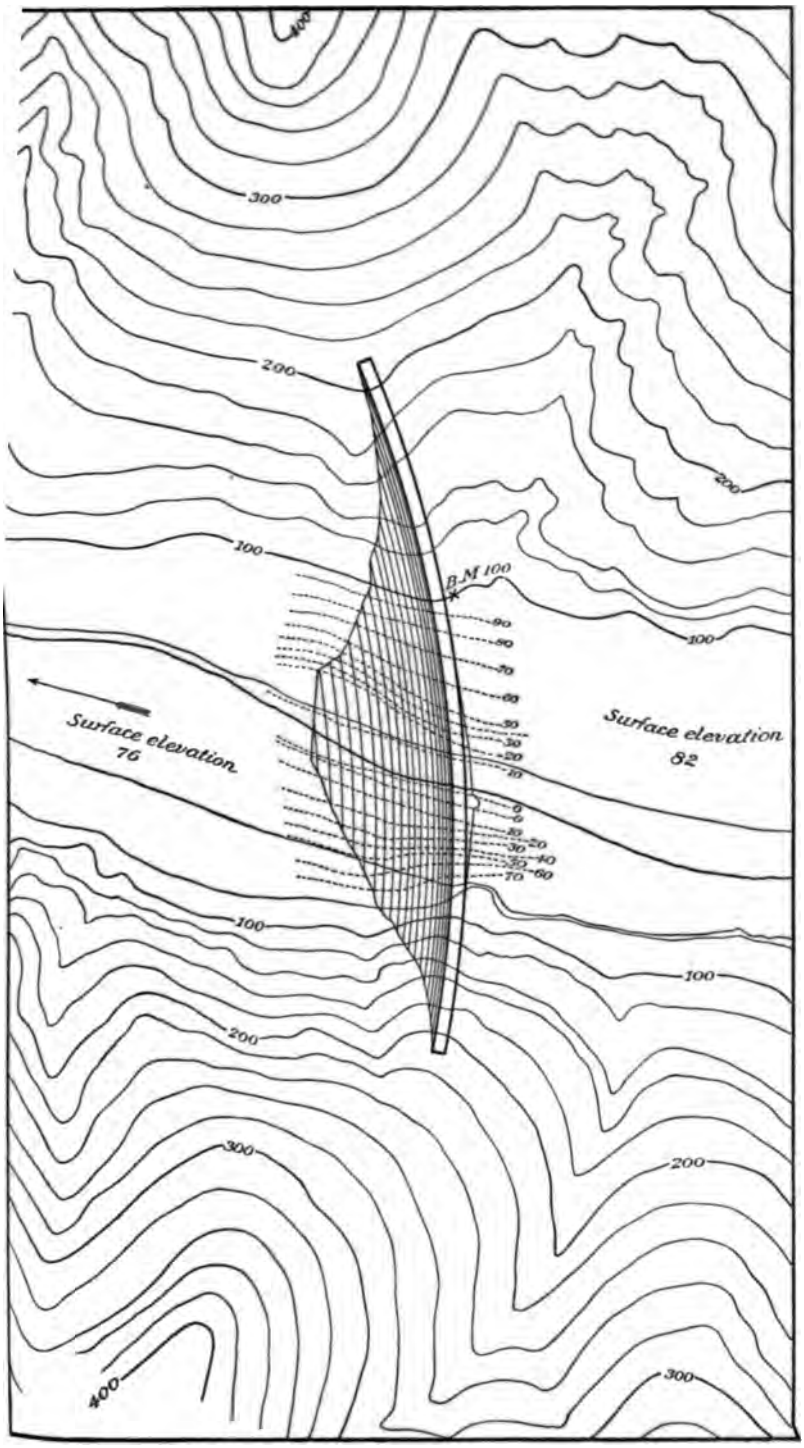
Area and capacity of the Buttes reservoir site.

Contour flow line.	Area.	Capacity, section.	Capacity, total.
	Acres.	*Acre-feet.*	*Acre-feet.*
10	20	100	100
20	71	450	550
30	229	1,500	2,050
40	397	3,130	5,180
50	533	4,650	9,830
60	741	6,370	16,200
70	928	8,345	24,545
80	1,105	10,165	34,710
90	1,329	12,170	46,880
100	1,566	14,475	61,355
110	1,769	16,675	78,030
120	2,029	18,990	97,020
130	2,367	21,980	119,000
140	2,746	25,565	144,565
150	3,149	29,475	174,040
160	3,602	33,755	207,795
170	4,118	38,600	246,395
180	4,609	43,635	290,030
190	5,133	48,710	338,740
200	5,651	53,920	392,660
		392,660	

Estimate for the Buttes dam.

Rock excavation for dam and riprap, 305,805 cubic yards, at $1	$305
Masonry in walls above ground, 137,032 cubic yards, at $6	822
Concrete tower, 37,328 cubic feet, at 50 cents	18
Tower house	
8 inlets, at $500 each	4
4 balance valves, at $1,000 each	4
Footbridge, 120 feet, at $10 per foot	1
Masonry below water:	
Lower wall, 478,800 cubic feet, at 90 cents	43
Upper wall, 798,800 cubic feet, at 70 cents	55
Steel plates in face wall:	
1,152,000 pounds, at 7 cents	8
Low-water tunnel, 1,000 feet, at $15	1
Tower for flood gate	1
Tower house	
Right of way	1
Upper outlet tunnel, lined, 320 feet, at $15	4
Bulkhead for same, 200 yards concrete, at $10	2
Woodcrib diversion dam at head of Florence canal, 500 feet, at $40 per linear foot	2
	2,29
Engineering and contingencies, 15 per cent	344
Total	2,643

Cost per acre-foot of water stored, $15.19.



CONTOUR MAP OF RIVERSIDE DAM SITE.

DIVERSION CANAL BELOW THE BUTTES DAM.

A topographic map was made on a scale of 100 feet to the inch, with 5-foot contours, showing possible locations of a diversion canal from the Buttes dam site to a point near the head of the Florence canal, which is practically at the head of the irrigable lands to be supplied from this reservoir. This topography was mapped by Mr. Bradford Wheeler, of Los Angeles, California. A grade line for the proposed conduit was computed. Flags were then set with a level upon the 10-foot contour nearest the grade from the dam through to the head of the irrigable lands. A transit stadia line was then run between these contour flags, transit points being set at intervals not to exceed 500 feet. This transit line was then plotted upon plane-table sheets, which were taken into the field, and the topography was filled in by means of the plane table. Instructions were to keep the accuracy of the map within the limit of the contour interval. The elevation of the contour flags was the vertical control for the work and the angular transit line was the horizontal control.

Upon this topographic map the canal location has been studied. The outlet tunnel, on the west bank of the reservoir, is placed at an elevation of 30 feet above the bed of the stream, the storage capacity lost below this elevation being immaterial. This would afford a bed-rock diversion and no loss by seepage. The capacity of the proposed canal is 500 cubic feet per second. The grade of the canal being lighter than that of the river permits of a gain in relative elevation and the possible development of power. The principal point gained by the construction of a canal as planned would be one of power.

A drop of 18.11 feet could be obtained at station 79+80, which, with 500 second-feet in the canal, would develop about 800 horsepower. If this horsepower could be sold at $50 per horsepower per annum, it would pay 5 per cent on a capital of $800,000. In a settlement such as would be built up upon the irrigation of 100,000 acres of land this power might be sold. When the time arrives that would make the power of sufficient value to justify the construction of the canal, it may then be built. Prior to that time the water from the outlet tunnels can be discharged into the bed of the Gila River and diverted at the present head of the Florence canal, where projecting ledges of rock are suitable for that purpose. The cost of the construction of this canal, therefore, should not be an element in estimating the cost of the Buttes dam. The water from either the Riverside or San Carlos reservoirs, which would be discharged directly into the Gila River, would necessarily be diverted for irrigation purposes at the head of the Florence canal, which is the point where water from the Buttes reservoir site could also equally well be diverted.

Cost of the Buttes canal.

15,510 lineal feet of lined canal, in rock, at $8.80 per lineal foot	$136,488
400 lineal feet of lined canal, in loose rock, at $6.73 per lineal foot	2,692
5,120 lineal feet of earthen canal, 57 cubic yards excavation, per lineal foot, at 30 cents per cubic yard, $1.71 per lineal foot	8,755
580 lineal feet of lined tunnel, at $10.65 per lineal foot	6,177
610 lineal feet of earthen canal, lined, at $7.94 per lineal foot	4,843
1,960 lineal feet of flume and trestle, at an average cost of $17 per lineal foot	33,320
24,180 lineal feet of conduit	192,275
Engineering and contingencies	28,840
Total	221,115

4.59 miles, or about $48,000 per mile.

EXPLORATION AT THE DIKES.

Four miles above the Buttes dam site, on the Gila River, a dike of volcanic rock, apparently of more recent geological origin than the remainder of the country, crosses the stream. After the depth to bed rock at the Buttes was determined to be disappointingly great, it was thought possible that the depths might be less at the Dikes. A test was therefore made to determine this. Pipe was driven to a depth of 96 feet and 3 inches in the center of the canyon without reaching bed rock. As the width of the canyon at this point is 459 feet between the rock croppings at the two sides of the canyon, and as the better portion of the Buttes reservoir site in the way of capacity lies between the Buttes and the Dikes, this depth to bed rock is considered as having condemned that location for the construction of a dam.

RIVERSIDE RESERVOIR.

The Riverside reservoir site is located on the Gila River, in Pinal County, Arizona, between the mouth of the San Pedro and a point one-half mile below the mouth of Mineral Creek and 12 miles above the Buttes (Pl. XVIII.) The dam site is in a canyon one-half mile below the mouth of Mineral Creek. A view of this canyon, looking downstream, is shown on Pl. XVII, *A*.

The water supply at this point will be practically the same as that at the Buttes. There are no streams or drainage lines of consequence entering the river between the Buttes dam site and the dam site of the Riverside reservoir. The discussion of the water supply in the previous pages of this report will apply equally to the Riverside reservoir site and the Buttes.

The bed of the canyon between the projecting ledges at the two abutments is 350 feet in width. A bench mark is located on the right bank, 20 feet above the bed of the stream. It is a bronze tablet, set in the rock, such as is used to designate elevations by the Geological Survey. It is considered 100 feet above the datum plane of the dam and reservoir surveys.

A RIVERSIDE DAM SITE, LOOKING DOWNSTREAM

B RIVERSIDE RESERVOIR SITE.

This elevation of 100 feet is equivalent to 1,763.30 feet above sea level. The rock at this location is a granite, well suited for building purposes. The topographic survey of the dam site was made by Gerard H. Matthes, assistant hydrographer, United States Geological Survey, in 1899, on a scale of 100 feet to the inch, and with a contour interval of 10 feet. A dam has been projected upon this map as a basis for an estimate for this report at the point where bed rock was determined by the diamond core drill. The height of the dam above the bed of the stream as estimated is 133 feet; the maximum depth to bed rock is 78 feet, or a total height of structure of 211 feet. Large ledges of rocks are available for construction purposes at an elevation above the dam on either side of the canyon.

The accompanying map (Pl. XVI) shows by means of contours the walls of the canyon and also the location of the dam described above. This has been prepared from the detailed map made by Mr. Matthes, the 20-foot contour lines only being given. The dotted lines in the center of the map indicate the depth to bed rock as shown by the drill holes. The point marked "B. M. 100" on the map is at an altitude of 1,763.3 feet above sea level. The surface elevation of the bed of the stream immediately above the proposed dam is 76.8 feet, and immediately below, 76.1 feet. Five borings to bed rock were made along the upper face of the dam and six along the lower side, the position of these being shown on Pl. XIV, *C*.

PROPOSED DAM AT RIVERSIDE.

The dam at this point should be an overflow weir, as the topography is not suited to the artificial construction of spillways on either side. The bed rock developed by the borings is a heavy granite, suited to withstand any pressure that may be put upon it by a dam. The quality of the building material, the topography, compelling an overflow weir, and the substantial character of the bed rock, determine a masonry structure as the best suited for this site. The section of dam proposed for San Carlos (Pl. XXII), described in detail under the discussion of that reservoir site, is the one selected as the basis of the estimate for the Riverside reservoir.

Eleven holes were put down with the diamond drills, their position being shown on Pl. XIV, *C*, at the point selected for the dam, and cores of bed rock were obtained. These borings are distributed across the canyon on two lines 150 feet apart, the holes in each row being between 50 and 60 feet distant from one another. The specific gravity of the rock is 2.51 and its weight per cubic foot is 157 pounds. Its strength to resist pressure was beyond the limit of the testing machine used, 2,565 pounds, which is equivalent to 184 tons per cubic foot. This guarantees it to be strong enough for the purpose required. The following table gives the log of the holes at this dam site. Two additional holes were put down 380 feet above the accepted

dam site, in order to determine whether bed rock was neare face at this point. One hole went down to an elevation above the datum plane, or 76 feet in depth, and the other vation of 11 feet, or a depth of 68 feet. Bed rock was not tered at either one of these points, and as the canyon is w than below, it is evidently inferior to the site where the borings were made. Hence no alternative selection was at

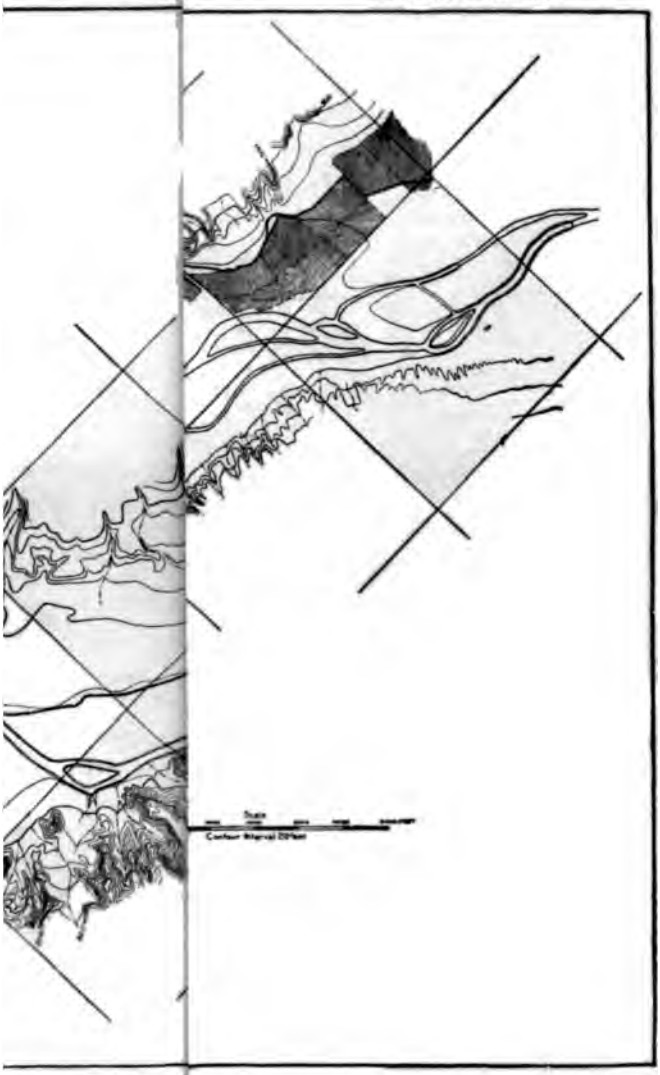
Log of holes at Riverside dam site.

Line.	Hole No.	Depth to bed rock.	Depth drilled in bed rock.	Elevation of bed rock.	Quality of rock.
		Feet.	*Feet.*	*Feet.*	
A	1	74.0	1.33	1,667.3	Hard driving.
A	2	75.5	5.00	1,664.7	Hard driving at 50 feet; bowlde
A	3	27.00	4.00	1,713.1	
A	4	32.75	4.25	1,713.3	
A	5	16.00	.66	1,734.1	
B	1	48.00+	2.00	.....	Bed rock doubtful.
B	2	44.33+	.....	.....	No bed rock; bowlders
B	3	31.00+	.....	.....	Very hard driving; no bed rock.
B	4	73.50+	.....	.....	Do.
C	1	24.00	2.00	1,716.9	Gravel and sand.
C	2	49.00	3.00	1,690.4	Bowlder.
C	3	69.00	3.25	1,670.7	Bowlders.
C	4	64.33	5.16	1,673.7	Do.
C	5	65.00+	.....	.....	Bed rock doubtful; possible ed cliff.
C	6	27.00	2.25	1,729.0	
C	7	63.00	10.75	1,682.9	

NOTE.—Add 1,663.3 to elevation on contour maps for sea datum.

METHOD OF CONSTRUCTION.

As the quarries from which the material for the dam may be can be properly located approximately on the axis of the s cableways could probably be best used for putting the rock The method of excavating to bed rock at this point might be ommended at the Buttes, although it is possible that furthe gation may determine that simpler methods of excavatio sufficient. Sand suitable for concrete work may be found beds throughout the canyon. Along the wagon road from t side stage station to Globe large ledges of quartzite occur. this material have rolled down the drainage line practicall River and at distances not exceeding 4 miles from the dam si quartzite when ground is suited for mixing with finely grou land cement for making silica cement. This would cheape of cement for the construction of a dam. The railroad statio material for the dam will be shipped is Casa Grande. The f cement from Los Angeles to Casa Grande is $12.20 per ton, per barrel. There would then be a wagon haul of 50 miles o good roads from Casa Grande to the dam site. This haul w approximately $1.35 per barrel. With cement at $2.85 per Los Angeles, the cost delivered at the dam would be $6.52. A feet in height across the bed of the stream, as described abo *require 186,147* cubic yards of masonry.



'ERSIDE RESERVOIR

CAPACITY AND COST OF RIVERSIDE RESERVOIR.

The Riverside reservoir site was surveyed by Gerard H. Matthes, assistant hydrographer, U. S. Geological Survey, and mapped on a scale of 1,000 feet to 1 inch, with contour intervals of 10 and 20 feet, reaching an elevation of 214 feet above the bed of the stream at the dam site, which is the 290-foot contour of the reservoir survey. With a height of dam of 133 feet, or to the 210-foot contour, the length of the reservoir would be approximately 14 miles, and to the 230-foot contour, or a height of dam of 153 feet, approximately 15½ miles. The width varies at different points from a half mile to a mile. The principal breadth is from 3 to 6 miles above the Riverside stage station. A dam 130 feet in height to the spillway at the Buttes would store 206,000 acre-feet. A dam 133 feet in height at Riverside will impound 221,134 acre-feet, which is almost double the capacity of the Buttes reservoir site. A dam 130 feet high to the spillway at San Carlos will impound 241,396 acre-feet, which is the best of the three for this size of dam. With a dam 150 feet high to the spillway at the Buttes, which is the height upon which the estimate is based, 174,040 acre-feet would be impounded. A dam at Riverside of a height of 153 feet would impound 344,398 acre-feet, which is double the capacity of the Buttes, and a similar dam of 150 feet at San Carlos would impound 377,176 acre-feet.

The Riverside reservoir site is situated in a mineral district. Copper is found in large quantities in this neighborhood, and in August, 1899, there were 29 copper claims that would be wholly or in part flooded in case a dam 150 feet in height should be built. These claims are not being worked commercially, but are at present "prospects." With a railroad built to this mineral field, it is quite likely that a number of these claims could be worked at a profit. The Ray mine, which is being actively worked, is a short distance above the reservoir site on Mineral Creek. The owners are making an effort for the construction of a railroad to the mines. It would be undesirable to interfere with mining operations, which might develop valuable properties if interference could be avoided. The condemnation of right of way would be one of the greatest expenses in connection with the utilization of this reservoir site for storage purposes. It is probable that it would cost $200,000 without court expenses, which would easily amount to $50,000 more. There are under cultivation at present in the reservoir site 332 acres of land. These fields are irrigated by a small ditch. There is held in private ownership in the reservoir site 1,800 acres. This land would probably cost $20 an acre to condemn, or a total of $36,000.

Capacity of proposed Riverside reservoir.

Contour flow line.	Height of dam above bed of stream.	Area.	Capacity of section.	Total capacity.
	Feet.	*Acres.*	*Acre-feet.*	*Acre feet.*
80	3			
90	13	28	196	196
110	33	197	2,252	2,447
130	53	600	7,972	10,419
150	73	1,311	18,005	28,424
170	93	2,316	36,270	64,694
190	113	3,967	62,832	127,526
210	133	5,395	93,607	221,134
230	153	6,924	123,174	344,308
			344,308	

NOTE.—Elevations based on datum of dam survey; 100 feet = 1,763.30 sea datum.

Estimate of cost of Riverside dam.

Masonry (half large rock and half concrete), 186,147 cubic yards, at $4.10 per barrel for sand cement, or $3.74 per cubic yard for cement (see Duryee's report), at $5.50 per cubic yard		$1,023,809
Excavating for foundations, 90,740 cubic yards		480,000
Towers and houses		12,000
Valves		3,500
Footbridges		6,000
Wooden crib diversion dam at head of irrigation canal		20,000
Total		1,515,309
Contingencies, 10 per cent	$151,531	
Engineering, 5 per cent	75,765	
		227,296
Total construction cost		1,742,605
Damage and condemnation proceedings		250,000
		1,992,605

Total number of acre-feet stored is 221,134, at a rate per acre, stored, of $9.01.

SAN CARLOS RESERVOIR.

San Carlos reservoir site is located on Gila River, on the White Mountain Indian Reservation, at the San Carlos Agency, in Gila County, Arizona, at a point where San Carlos River joins the Gila. The Gila Valley, Globe and Northern Railway, which leaves the main line of the Southern Pacific at Bowie Station and runs to the town of Globe, passes across this reservoir site. The Gila River at this point traverses some spurs of the Pinal range of mountains, and for a distance of 31.5 miles below the dam site the river flows in a narrow box canyon. This canyon extends to Dudleyville, which point is the upper end of the Riverside reservoir site. The river then passes through the Riverside reservoir site for a distance of 15.5 miles, after which it again enters a canyon, which is the upper end of the Buttes reservoir site. This latter canyon extends to the Dikes, which is 4 miles above the Buttes dam site. The total length of river from San Carlos dam site to the Buttes dam site is approximately 60 miles; about 40 miles of this distance being box canyon, and the remaining portion being valley land, of from 1 to 3 miles in width.

SAN CARLOS DAM SITE, LOOKING UPSTREAM.

Six miles below the San Carlos Agency, where the river enters the ox canyon and approximately a half mile below the beginning of the ox, is a point where the canyon is about 90 feet wide at the water line nd where its walls rise very abruptly directly from the river. Pl. IX shows a view of the dam site looking upstream. The dam will e located at the point where the wall of the canyon is shown to be ost abrupt. Pl. XX shows the dam site as surveyed, with a contour nterval of 10 feet. The dotted contours show bed rock as indicated y the borings. At a point approximately 100 feet above the upper ace of the location selected for the dam there has apparently been a ault in the rock of the canyon. If the dam were located above this ault, there would be the possibility of a leak occurring between the trata and of water passing through the fault to the channel of the iver below the dam. If the dam is built where located, this will be bviated.

The narrowest portion of the canyon is approximately 400 feet in ength, and immediately below this narrow point it widens out to 300 eet at the low-water line. This admits of a spillway provision as hown in the plan of the dam (Pl. XX) and described in the account f the dam proper. The dam is located at the point shown in the lan, therefore, in order to obtain better spillway advantage, to secure etter foundations and abutments, and to avoid the leakage through he strata above the line of fault.

The question of water supply available at San Carlos has been fully reated in preceding pages of this report in the discussion of supply vailable at the Buttes and at San Carlos, to which reference is made. he supply is ample to fill the reservoir with a dam 130 feet in height the spillway, as planned. The table on the following page shows he amounts probably available at the San Carlos reservoir for each onth. In this table the inflow, consumption, and evaporation are eated in the same manner as in the table on page 33, under the dis- ssion of water supply for the Buttes reservoir site. It has been etermined that the difference between the amount of water available r storage at San Carlos and the Buttes was 10 per cent, and this eduction of 10 per cent has been made in all estimates for the supply San Carlos as measured at the Buttes.

The water which is released from the San Carlos reservoir site will ass through approximately 40 miles of box canyon on its way to the rigable lands where it is to be used. Comparative measurements ade at the Buttes and San Carlos during the dry season of the year, hen less than 10 second-feet of water was flowing in the river at San arlos, indicate practically an equal amount of water at San Carlos nd the Buttes. There undoubtedly is a substantial loss from evap- ration between these points, but this loss is compensated for by the epage water which returns from the Riverside Valley and from the alley above the Buttes dam site. In the case of the Riverside Val- y a few second-feet of water is used for irrigation, and the return

from this irrigation augments the stream. In both valleys, howeve the high stages of the river undoubtedly charge the sand bars a gravel beds with water, and these are gradually drained off durin the lower stages of the stream and, as has been stated, give practically an equal amount of water at San Carlos and the Buttes.

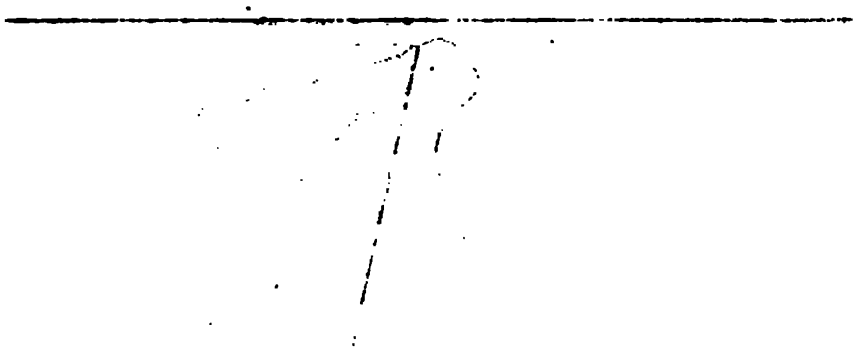
The San Pedro and the other drainage lines entering the Gila abov the Buttes and below San Carlos will contribute their portion to thi stream, unregulated by a reservoir built at San Carlos. This wate can be used for irrigation around Florence if diverted below. If thi volume of water and the return water from seepage is added to th water which is discharged for irrigation from the San Carlos reservoi site, it is probable that there will be available for irrigation at th point of diversion as much water as would be discharged from the Sa Carlos reservoir site.

If the Gila River from the San Carlos dam site to the Buttes dam site is 60 miles in length and 200 feet in width, it will expose to evaporation a water area of 1,454 acres. The depth of evaporation pe annum has been previously determined as 91 inches, or 7.58 feet With an area of 1,454 acres and a depth of evaporation of 7.58 fee there will be lost from this body of water 11,021 acre-feet. This woul be 4.6 per cent of the total capacity of the San Carlos reservoir site and, in order to make an allowance for all possible loss, 5 per cent o the water discharged from San Carlos is assumed as being lost for irrigation below the Buttes. The Riverside Valley and the valley abov the Buttes are both largely public domain, and there is no reason wh the water from the San Carlos reservoir should not be used for irrigation purposes at these points, as well as below Florence. This bein the case, there will be but a slight disadvantage in storing water at Sa Carlos. A loss of 5 per cent in transmission is accepted in the following table and added to the amount to be liberated from the reservoir

Estimated amount of water available from San Carlos reservoir.

[Capacity of reservoir is 241,396 acre-feet; 100,000 feet assumed to be in reservoir November 1.]

Month.	Inflow.	Per cent of capacity of reservoir used in irrigation.	Outflow for irrigation.	Loss of 5 per cent in transmission to point of irrigation.	Total amount turned out of reservoir for irrigation.	Depth of evaporation.	Area exposed to evaporation.	Loss by evaporation from reservoir.	Total loss from irrigation and evaporation.	Balance in reservoir at end of month.
	Acre-ft.	*Per ct.*	*Acre-ft*	*Acre-ft*	*Acre-ft*	*Feet.*	*Acres.*	*Acre-ft*	*Acre-ft*	*Acre-ft.*
November	32,842	2	4,828	241	5,069	0.42	3,650	1,533	6,602	126,240
December	27,117	2	4,828	241	5,069	.333	4,100	1,353	6,422	146,935
January	36,745	2	4,828	241	5,069	.25	4,690	1,173	6,242	177,438
February	24,008	5	12,071	604	12,675	.333	5,130	1,710	14,385	187,061
March	21,405	7	16,898	845	17,743	.50	5,225	2,612	20,355	188,109
April	18,433	9	21,725	1,086	22,811	.58	5,760	3,341	26,152	180,390
May	7,227	14	33,795	1,690	35,485	.83	4,680	3,884	39,369	148,248
June	3,665	14	33,795	1,690	35,485	.92	3,110	2,861	38,346	113,567
July	59,170	13	31,381	1,569	32,950	1.00	4,060	4,060	37,010	135,727
August	69,522	13	31,381	1,569	32,950	1.08	4,370	4,720	37,670	167,579
September	47,256	11	26,554	1,328	27,882	.83	4,950	4,109	31,991	182,838
October	74,800	8	19,312	966	20,278	.50	5,714	2,857	23,135	234,501
Total	*422,184*	100	241,396	12,070	253,466	7.58	.....	34,211	287,477	.....



There is still an amount available for irrigation below the Buttes, n the basis of the above table, for a mean year, equal each year to ne full capacity of the San Carlos reservoir, of 241,396 acre-feet, with minimum reserve in reservoir of 113,567 acre-feet, and 234,507 acre-et on November 1, for use during the following season. The dis-harge of the Gila River during 1899 was less than during any other ear of which we have record. The following table demonstrates hat 241,396 acre-feet of water could have been delivered below the uttes from San Carlos from November 1, 1898, to October 31, 1899, ith a minimum reserve in the reservoir during that period of 12,269 ere-feet and 96,088 acre-feet in reservoir with which to begin the eason of 1899–1900:

Estimated amount of water available from San Carlos reservoir during 1898–99.

apacity of reservoir, 241,396 acre-feet; 100,000 acre-feet assumed to be in reservoir November 1, 1898.]

Month.	Inflow.	Per cent. of capacity of reservoir used in irrigation.	Outflow for irrigation.	Loss of 5 per cent. in transmission to point of irrigation.	Total amount turned out of reservoir for irrigation.	Depth of evaporation.	Average area exposed to evaporation.	Loss by evaporation from reservoir.	Total loss from irrigation and evaporation.	Balance in reservoir at end of month.
	Acre-feet.	*Per cent.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Feet.*	*Acres.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*
1898.										
November	5,409	2	4,828	241	5,069	0.42	3,460	1,453	6,322	98,887
December	16,878	2	4,828	241	5,069	.333	3,560	1,185	6,254	109,511
1899.										
January	17,555	2	4,828	241	5,069	.25	3,710	928	5,997	121,069
February	11,946	5	12,071	604	12,675	.333	3,700	1,232	13,907	119,108
March	7,194	7	16,898	845	17,743	.50	3,600	1,800	19,543	106,759
April	3,320	9	21,725	1,086	22,811	.58	3,310	1,920	24,731	85,348
May	996	14	33,795	1,690	35,485	.83	2,650	2,200	37,685	48,659
June	276	14	33,795	1,690	35,485	.92	1,610	1,181	36,666	12,269
July	65,754	13	31,381	1,569	32,950	1.00	1,570	1,570	34,520	43,503
August	a 24,884	13	31,381	1,569	32,950	1.08	2,060	2,214	35,164	33,223
September	39,280	11	26,554	1,328	27,882	.83	2,000	1,660	29,542	42,941
October	b 74,800	8	19,312	966	20,278	.50	2,730	1,373	21,653	96,088
Totals	268,272	100	241,396	12,070	253,466	7.58	.....	18,718	272,184	.....

a Measured discharge of Gila Basin at San Carlos.
b Estimated mean discharge, in acre-feet, of Gila Basin above San Carlos for month of October, 99.

PROPOSED DAM AT SAN CARLOS.

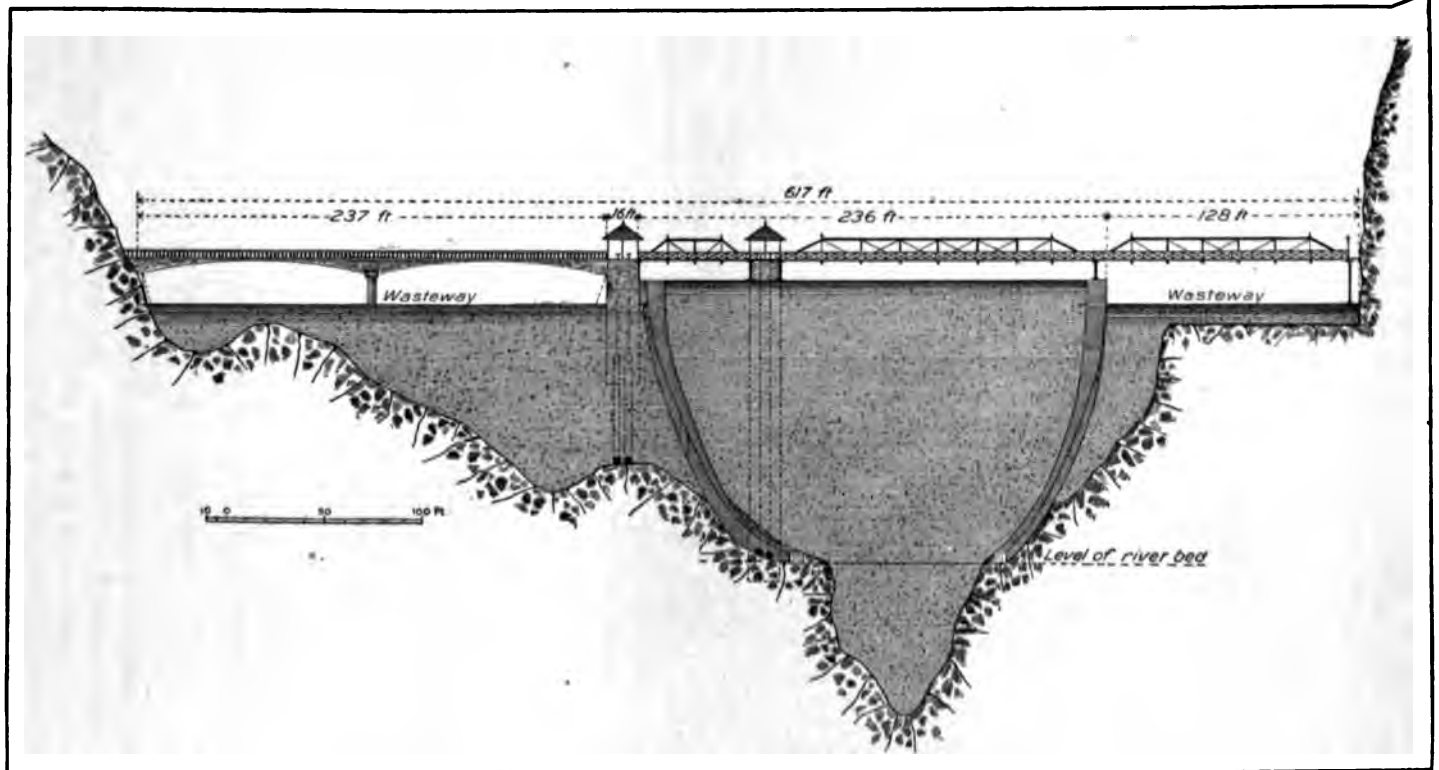
In determining the height of dam to be constructed at the San Carlos am site two elements are to be considered. First, the amount of ater available; second, the amount of expenditure which can be conomically made. From a study of the water supply, shown on age 29, a dam 130 feet in height, storing 241,396 acre-feet, is justified. he year of lowest run-off of which we have a record is 1899. The lischarge of the river for this year at San Carlos was measured until he 1st of October, and a monthly discharge for October, November, nd December, as determined, has been added to complete the year.

This shows a surplus for the year 1899 above the capacity of the reservoir of 76,879 acre-feet. The mean surplus above the capacity of the reservoir at San Carlos is estimated at 180,788 acre-feet. The maximum height of the central portion of the dam above the bed of the stream is taken at 142 feet, and the maximum depth to bed rock below the surface of the stream at 74 feet. This would give a total maximum height of the central portion of the dam from bed rock at 216 feet. An increase of this height is considered unnecessary and as adding too much to the expense of the structure. The table on page 69 is believed to justify a dam of this size.

The San Carlos reservoir site was the last that was discovered upon the Gila River, and consequently the last point at which investigation for bed rock was made. After the completion of the borings at Queen Creek, the Buttes, and Riverside, the drilling outfit, in charge of Mr. Patrick Tierney, was sent by wagon from Riverside to San Carlos. This arrived at San Carlos in the latter part of June, 1899, and work was immediately begun at the dam site. The first flood on the Gila River in the summer of 1899 occurred on July 16 and was about 10,000 cubic feet per second in volume. This knocked over the drilling apparatus. It was restored to position, and frequent other interrupting floods occurred at intervals of two or three days during the remaining portion of July. The funds available for carrying on the work having become nearly exhausted, and the river continuing its flood discharges, it was not considered practicable to continue the investigation for bed rock during the present season.

Two holes were put down approximately on the lower toe of the dam. No. 1 was 33 feet to the right of bench mark No. 4, which is located on the left abutment, and No. 2 was 66 feet from the left abutment and approximately 30 feet from the right abutment. The depth to bed rock at hole No. 1 was 23 feet. The bed rock encountered is a very fine-grained and flinty limestone. It was so hard that only 2 feet 9 inches a day could be drilled into it with the diamond drills, which is about one-fourth the rate of progress in ordinary granite. The depth drilled into bed rock at this point was 12.5 feet.

Hole No. 2 determined the depth to bed rock to be 74 feet. Gravel was encountered at 72 feet. The rock at this hole is a blue limestone and is more easily drilled than the rock in hole No. 1. The total depth to the bottom of this hole was 81.82 feet, the depth drilled into bed rock being 7.82 feet. A third hole was put down in the center of the bed of the canyon 60 feet from the left abutment and 100 feet above line No. 1. A 2-inch pipe was driven to a depth of 56 feet and 2 inches, when it was found to be bent 2 feet from the bottom. The pipe was then pulled up and 2½-inch pipe driven to a depth of 51 feet in the same hole. No further progress could be made on account of the high water, and this hole was abandoned and all work stopped on July 31, 1899.



ELEVATION OF SAN CARLOS DAM AND WASTEWAYS.

The information concerning bed rock is meager, but it is considered r to estimate the maximum depth of bed rock at 74 feet. The bed-ck itself is a very close-grained hard limestone and all that could desired for foundation purposes. The location of the borings at n Carlos dam site is shown on Pl. XX.

MATERIAL FOR DAM.

Pl. XXV, *B*, shows a view of the left abutment of the dam. The rata dip downstream. It would be better if the dip were upstream, there would be less danger of leakage beneath the foundation of the m. The limestone, however, is exceedingly dense, not easily eroded, d, as will be seen on the right-hand side of the illustration, where slide has occurred, the rock a few feet beneath the surface is rela-ely free from seams. The abutment on the right is of much the me nature as the abutment on the left.

The rock for the construction of the dam will be obtained near the p of the two abutments. It will be excavated in such manner as to rm a channel for the flood waters to discharge over the two weirs, ich are located at the two ends of the dam. Sufficient rock will be ken from these two channels, as shown by the plan, Pl. XX, to ild the entire structure, and this will be enough to furnish flood annels for the maximum flood at this point, which is estimated to within 10 per cent of the maximum flood at the Buttes. These arries will be located at the end of the dam and practically on its is, and in such position that material can readily be handled by ans of cable for construction purposes. The haul of the material ll be on a down grade, and the average distance will not exceed) feet. This is considered an ideal location for the economic use of oles. The quarry rock has a specific gravity of 2.7, or a weight of 3 pounds per cubic foot.

On the left abutment it is an exceedingly fine-grained pink lime-ne, much resembling flint, but showing, by analysis, percentages follows: 55.92 carbonate of lime, 31 carbonate of magnesia, 3.70 ca, 6 alumina and ferric oxide, and 1 moisture. The gray lime-ne from the right abutment contains 96.65 carbonate of lime, 1.40 ca, 1.30 alumina and ferric oxide, 0.65 moisture. From an engi-ering standpoint it has the appearance of being a first-class build-; rock.

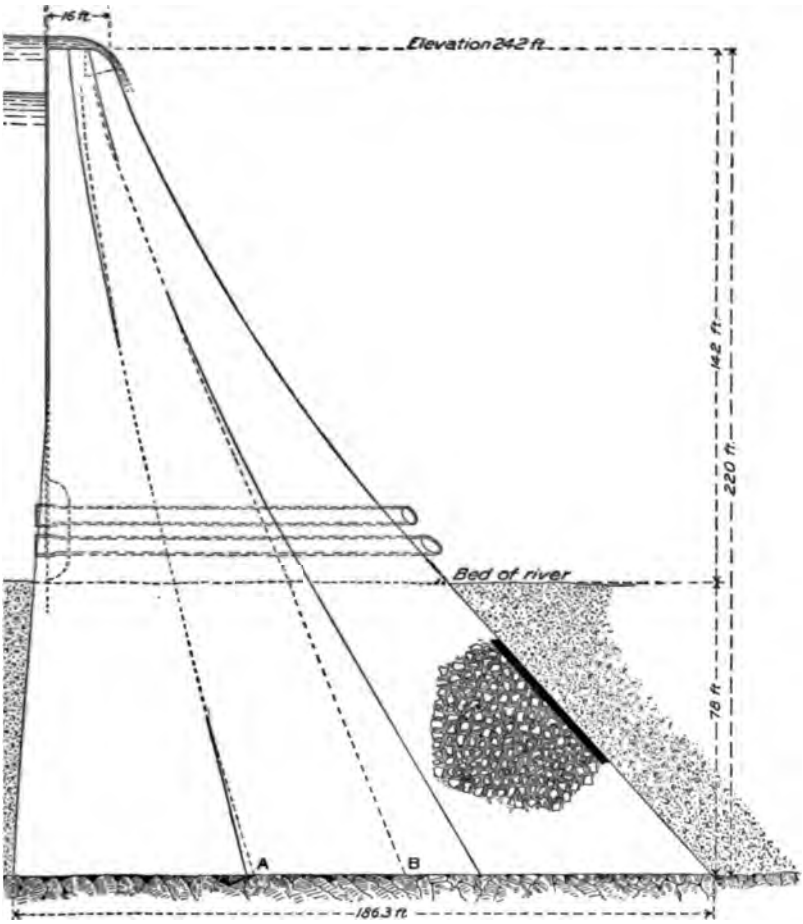
The sand required for the construction of the dam could be obtained the canyon within a few hundred feet of the dam site. It is a od building sand, but would have to be washed before its use with ment. Gravel in varying sizes is found in connection with the nd and could be separated from it by screening. The quartzite that ould be used at San Carlos is found in large ledges within 1,000 feet the dam site. Mr. Duryee's report on cement is given on page 82.

DETAILS OF DAM.

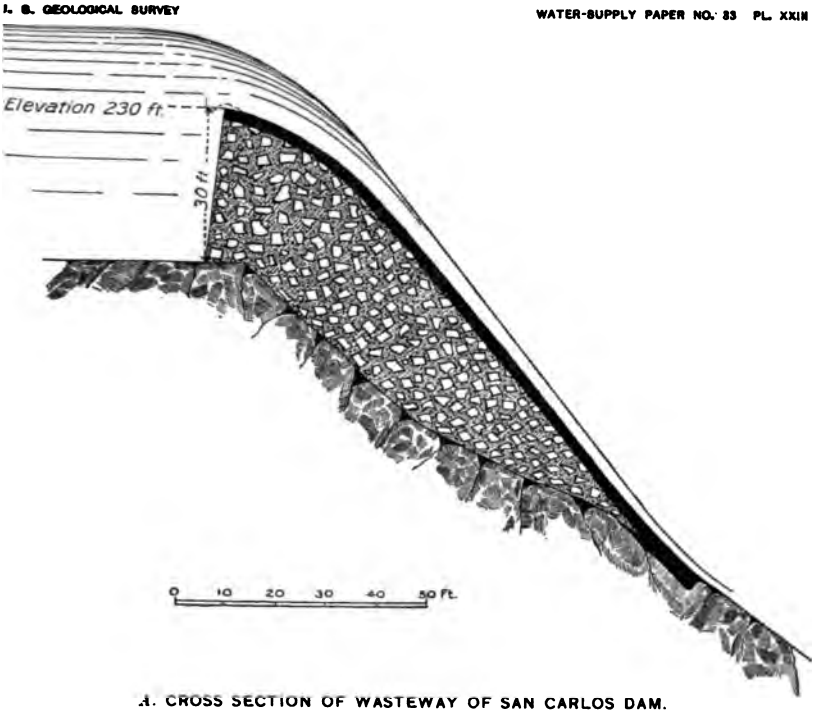
The dam selected for this site is shown in plan on Pl. XX, in section on Pl. XXII. The details are shown on Pls. XXI–XXVI. It is proposed to construct it of large irregular blocks of stone, bedded in concrete. The maximum height of this structure from deepest bed rock to the top of the central portion of the dam is 216 feet, and the maximum length is 617 feet. The total number of cubic yards contained in the dam, weir, and towers is 94,730. In order to avoid the erosion and shock which would result from a large flood passing over the central portion of the dam and falling 142 feet on its base, the middle part of the dam, for a length of 236 feet, has been planned to an elevation of 12.5 feet above the elevation of the wasteways on the sides. The section of the central portion of the dam (Pl. XXII) shows the line of pressure at B with 10 feet of water in depth passing over the crest, and also at A the line of pressure with an empty reservoir. Both these lines, for every portion of the dam, lie within the middle third, resulting in a safe gravity structure. The maximum pressure on the upper toe is 12 tons per square foot and on the lower toe 12½ tons per square foot. The weight of the masonry is assumed to be 150 pounds per cubic foot.

In addition to its strength as a gravity dam it is given an arched form. Expansion and contraction in a curved dam are more easily adjusted than in a straight dam. The spillway on the right bank (Pl. XXIII, *A*) would be 237 feet in length, and on the left abutment 128 feet in length. With 3 feet of water passing over the central portion of the dam and a corresponding depth of 15.5 feet discharged through the spillways over the two end weirs, the total discharge past the structure, exclusive of discharge through outlets, as estimated by T. C. Clarke's formula, is 83,620 cubic feet per second. This is considered as the maximum flood discharge of the Gila River at this point. It is fair to assume that the reservoir will not be wholly full at the time such a maximum flood would occur, and that the capacity of the reservoir will tend to relieve this flood discharge.

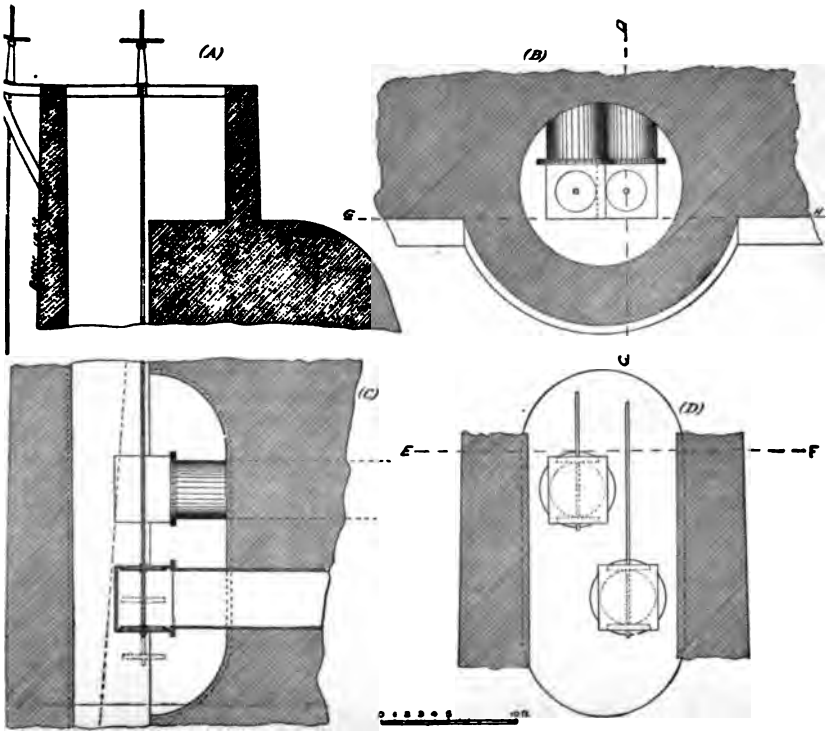
Two training walls have been planned from the ends of the central portion of the dam to protect its toe from the erosion of water passing over the spillways. This water will be discharged into the canyon below the lower toe of the dam in such manner as to project the overflow down the canyon away from the dam. The section of the wasteway weirs proposed for the two spillways is shown in Pl. XXIII, *A*. These weirs are to be built upon the sloping ledge rocks, and will have a slope on their lower face of 3 feet horizontally and 2 feet vertically. They will be of an exceedingly substantial nature, the surface being protected by from 2 to 3 feet of extra strong concrete. The water in passing over them will never leave the face, and consequently there will be no pounding action.



MAXIMUM CROSS SECTION OF THE SAN CARLOS DAM, WITH TOWERS REMOVED.

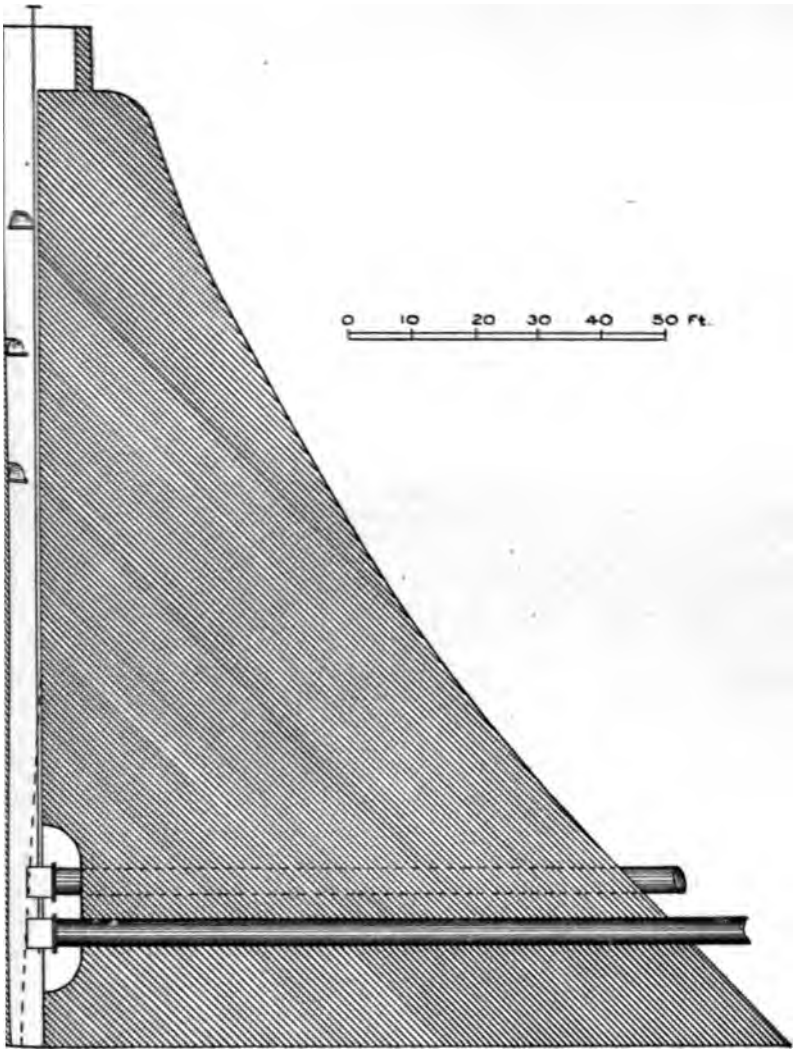


A. CROSS SECTION OF WASTEWAY OF SAN CARLOS DAM.



B. DETAILS OF TOWERS FOR SAN CARLOS DAM.

In the above figure sections are given of the outlet tower. At *B* is a horizontal section on the line *E F* of *D*; at *C* is the vertical section on the line *C D* of *B*, and at *D* is a vertical section on the line *G H* of *B*.



CROSS SECTION OF SAN CARLOS DAM THROUGH TOWER.

The outlet from the dam will be through two towers located near e right abutment. These towers will be semicircular, a portion of e opening being recessed into the dam, as shown by the details (Pl. XIII, *B*). A series of intakes will be placed in this tower at varying ıvations, the valve (Pl. XXVI, *A*) consisting of a plain cap or cover, shown in the detail, which will be lifted by an ordinary wheel and ew. The intakes will be pipes 3 feet in diameter, and there will be : in each tower (Pl. XXVI, *B*). As the water should be drawn from ar the surface of the reservoir at all times there will be very slight essure to be overcome in lifting these valves, and this may be overne by closing the balanced valves inside the tower, allowing the ter to fill with water through small by-pass valves, after which the essure on the outer intake valves will be relieved. In case any one the valves should become stuck, the water could be drawn into the ver from other valves, and when the general water plane fell below elevation of the injured valve it could then be repaired. A second of valves is to be located near the base of the tower. These valves ll permit the water to discharge through two cast-iron pipes which ll pass through the dam and which are to be 4 feet each in diameter. will be possible to discharge water through four of these pipes, o being located in each tower, as shown in the elevation of the dam. e discharge through these pipes will vary with the depth of water the tower.

As the valves for the discharge pipes may have to be operated der a considerable head of pressure, a balance valve has been cided upon as preferable. This valve is shown on Pl. XXIII, *B*. e action of this balance valve is in the nature of a double piston head, ich is driven by a screw gear from above. One of these valves, or ston heads, is seated on each side of the valve box. They are equal area, consequently the downward pressure on the upper valve is lanced by the upward pressure on the lower valve. When the lve is wide open one of these piston heads will be 2¼ feet below its ıt, and the upper piston head will be in the center of the boxing. e water will therefore enter through both openings and discharge rough the main pipe.

The towers were considered necessary in order to prevent the posit of silt around the valves, or their clogging with drift. In se the inner valves become out of order the outer valves can be sed and the inner valves then repaired. Two towers have been signed, so that one complete set of valves can get out of order and e second set be used during the repair of the first. A bridge from ch abutment to the towers has been planned, so that the dam may crossed and all points on the top of the dam visited, even during aximum floods. Alternate designs for this crossing are shown on e elevation of dam and wasteways, one for an iron bridge and the her for a combination iron and concrete span.

The safety of this structure, considering the remarkably hard bed rock on which it is to rest, the fine character of the building stone that may be used, the heavy gravity section of the dam and the weirs that have been planned, the solidity of the abutments and the narrowness of the canyon, would be beyond question.

At a point 180 feet above the upper face of the dam, marked "B. M. No. 1" on the plan (Pl. XX), the canyon is but 88 feet in width between the abutment walls. This is apparently an ideal place to put down sheet piling to bed rock to intercept the underflow. The surface flow of the stream would then be diverted in a flume to a point below the dam. It is believed that the sand and gravel of the river bed could be solidified by injecting cement grouting through pipes into the voids of the sand between the sheet piling and the foundation excavation. This could be injected at various points and elevations and the mass sufficiently solidified to admit of the excavation to bed rock at the site of the dam.

CAPACITY AND COST.

The capacity of the San Carlos reservoir with the height of dam proposed is the greatest of any of the reservoir sites that were found on the Gila River by this survey. The elevation of the bed of the canyon at the dam site is assumed by the surveys as 100 feet and is equivalent to a sea elevation of 2,307 feet, as determined from the San Carlos railroad station. A United States Geological Survey brass bench-mark tablet has been placed at the dam site. The capacity of the San Carlos reservoir site is shown in the following table:

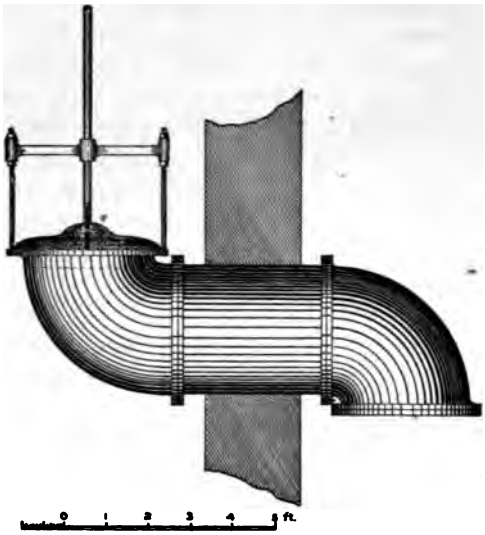
Capacity of San Carlos reservoir site.

Contour.	Area.	Contents between contours.	Total contents.	Mean depth.	Per cent of maximum depth.
	Acres.	*Acre-feet.*	*Acre-feet.*	*Feet.*	
100	0				
110	17.2	86.0	86.0	5.6	50.0
120	40.8	290.0	376.0	9.2	46.0
130	83.8	623.0	999.0	12.0	40.0
140	209.6	1,467.0	2,466.0	11.8	29.5
150	488.3	3,489.5	5,955.5	12.2	24.4
160	934.4	7,113.5	13,069.0	14.0	23.3
170	1,548.8	12,416.0	25,485.0	16.4	23.4
180	2,195.2	19,220.0	44,705.0	20.3	25.4
190	2,624.0	24,096.0	68,801.0	26.0	28.9
200	3,475.2	30,496.0	99,297.0	28.6	28.6
210	4,148.3	38,117.5	137,414.5	33.1	28.3
220	5,191.0	46,876.5	184,291.0	35.6	29.7
230	6,230.0	57,105.0	241,396.0	39.2	30.5
250	7,348.0	135,780.0	377,176.0	42.1	28.0
a 260			444,000.0		
a 270			512,000.0		
a 280			580,000.0		
a 290			650,000.0		
a 300			700,000.0		

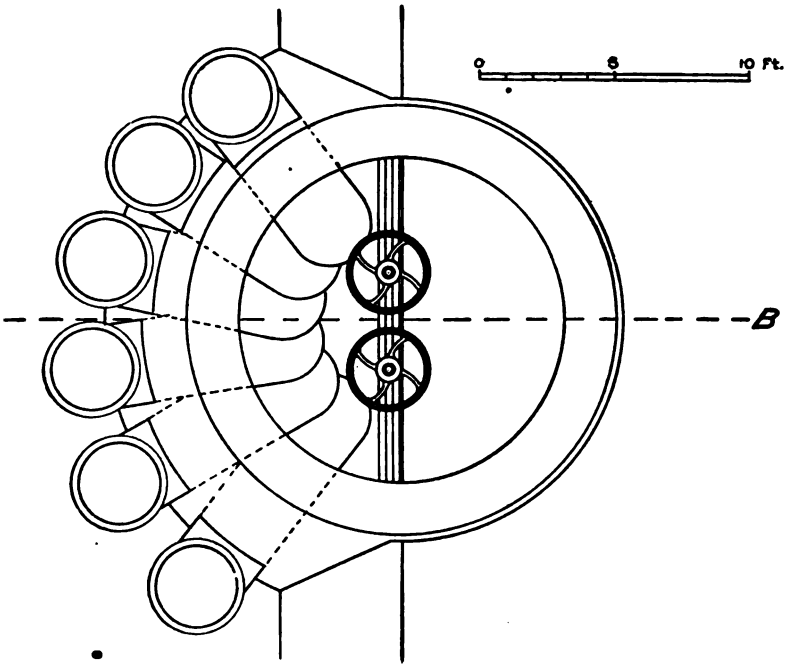
a Estimated.

A SAN CARLOS DAM SITE, LOOKING DOWNSTREAM

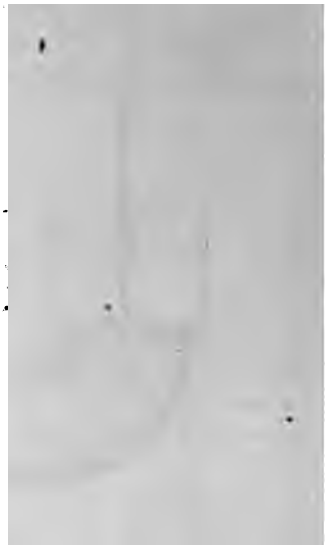
B LEFT ABUTMENT OF SAN CARLOS DAM SITE.



A. INLET VALVE FOR SAN CARLOS DAM.



B. HORIZONTAL SECTION OF MAIN TOWER OF SAN CARLOS DAM, SHOWING ARRANGEMENT OF VALVES.



The area that will be flooded by the construction of a dam at the ırrows will be on the Apache Indian Reservation. The question of ;ht of way would be the obtaining of the use of these reservation ıds. A plane-table survey of the reservoir site was made by Mr. rus C. Babb, on a scale of 2½ inches to the mile and with a contour :erval of 10 feet. From this survey it was found that 587 acres of ıds that have been irrigated and farmed by the Indians would be oded; that of the remaining area, 4,405 acres are irrigable, the nainder, 3,360 acres, being nonirrigable. No improvements have en made by the Indians other than the building of brush fences d houses. The Apache Indian is of a roving nature and does not :e to live for a long period of time upon one spot. It is said that ıen a death occurs in a family the house is abandoned and a new :ation is selected.

In order to provide for the damage which would be done to these dian farms, the estimate includes $20,000 for the construction of a ;w irrigation system for the Indians above the reservoir site. There as much water available from the Gila River at points between San ırlos and Geronimo as near the agency. Lands in that locality are ıoccupied, are of equal fertility, could be irrigated with equal ease, ıd are on the reservation. If, therefore, a substantial irrigation 'stem should be built for these Indians higher up on the river, and is should be given to them in lieu of their primitive and deficient 'stems that now exist, it is considered that the treatment would be ir.

When the Gila Valley, Globe and Northern Railway built through e reservation they paid the Indians at the rate of $40 an acre for e irrigated lands that were used for right of way and in addition ıve the tribe in general $8,000. These Indians are industrious and ıxious to work for wages whenever opportunity is offered. They ıilt the greater portion of the railroad through their agency. The ɔrk on the dam would extend over a period of two years or more, ıd the Indians may be given much employment in connection with is construction. It has been found in Mexico that as the water is n off from a reservoir crops may be raised upon the uncovered ıds, which have been completely saturated by the retiring water. ıese lands are found to be most productive. The Indians of San ırlos would have the opportunity of raising crops upon marginal ıds and would doubtless avail themselves of this opportunity.

The agency grounds and military post were surveyed in detail on a ale of 200 feet to the inch, with 5-foot contours. The essential fea-res of this map have been reproduced on Pl. XXVIII.

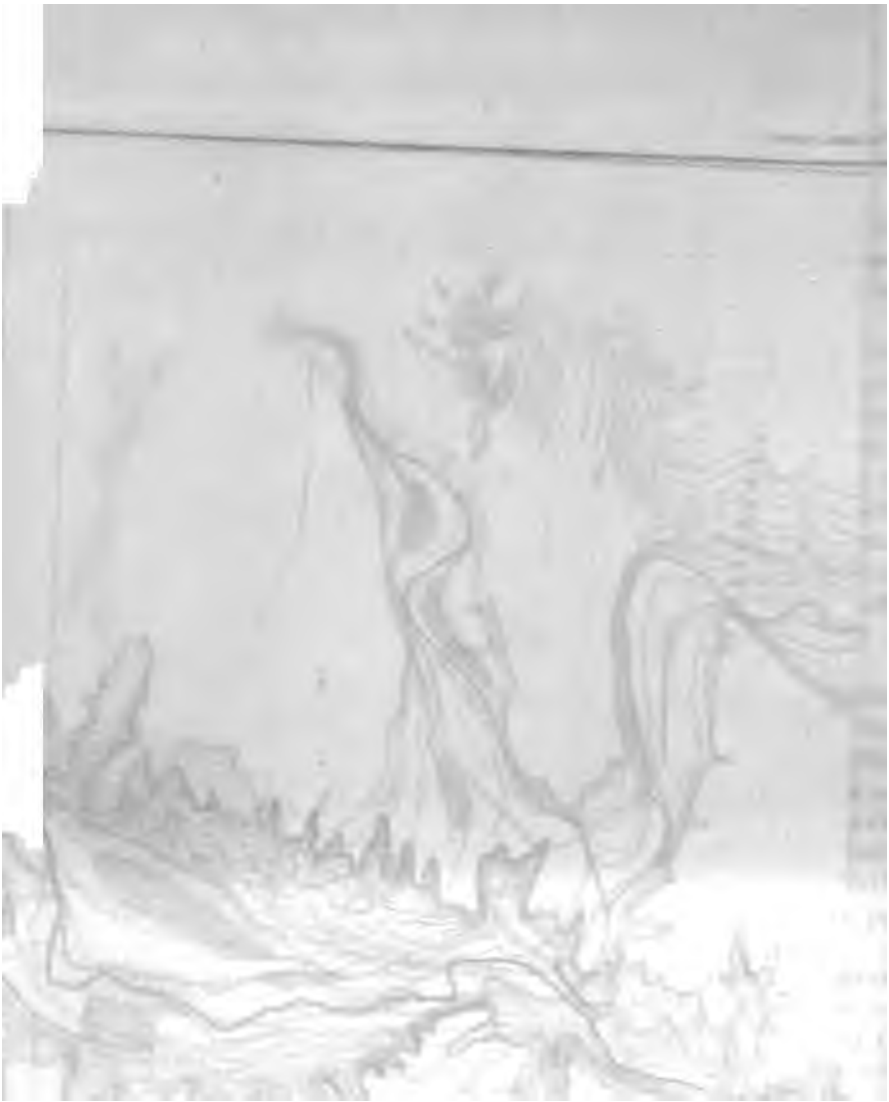
While the elevation of the spillway at the dam is 130 feet above the d of the stream, the flood line of the reservoir must be considered being at the maximum elevation of the water passing over the weirs, approximately 145 feet above the bed of the stream, or 245 feet

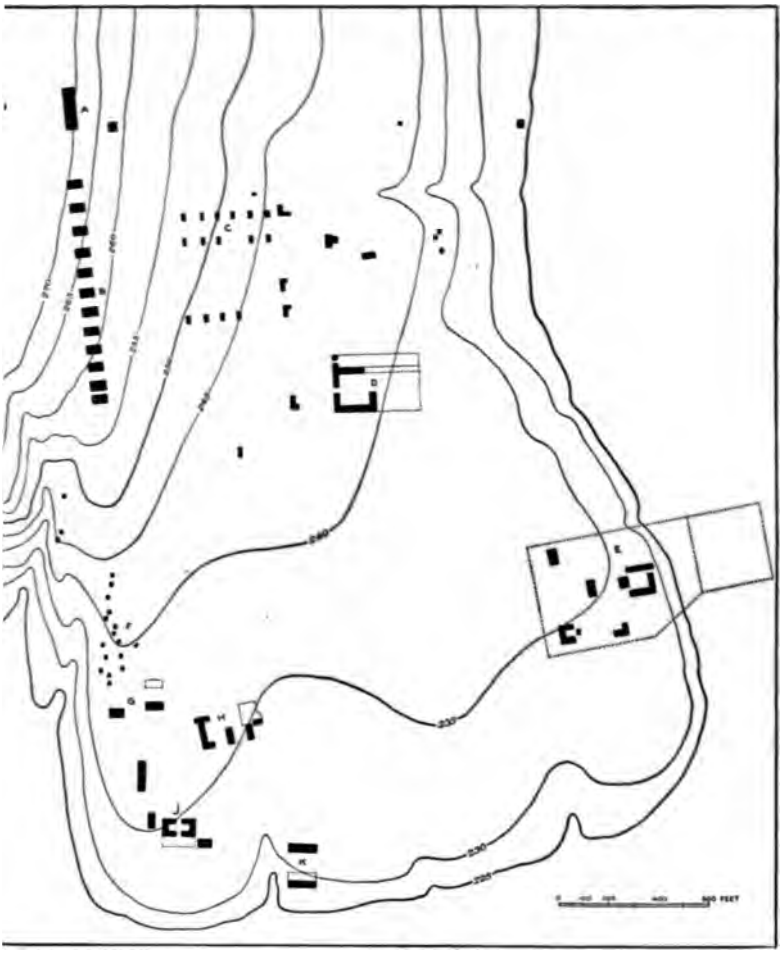
above the datum of the contour surveys. This contour, w would not include all the buildings of the military post and Indian agency, would cover so great a portion of the grounds remainder would be practically useless.

The agency and the post are both exceedingly dilapidated It has been proposed that the entire agency be moved to desirable location about 8 miles above, on the San Carlos where, in fact, the greater number of the Indians are loca handsome new school building, which has been provided for in appropriations, will not be located at the old agency, but at th higher up on the San Carlos. There is a stone school building house, and blacksmith shop at the agency. The officer's quar adobe, the post trader's building is a frame structure, and th twenty frame barracks. The quartermaster's department is of sheds, and the remaining buildings are either adobe or of lumber. They are all one-story structures except the school and are of a very ordinary type. There is a military ice and ing plant and an agency flour mill, which would be flooded reservoir.

After a careful consideration of all the buildings, and a dis of the situation on the ground with officers in charge and familiar with the value of the property, a total price of $60 considered as sufficient to provide for all damages done. Th has been included in the estimate. In view of the probable r of the agency to another location and the possible abandonm the military post, and considering the general state of dilapi which prevails, this figure of $60,000 for the building of a ne is considered as liberal.

As will be seen by reference to the map of the San Carlos re site, the Gila Valley, Globe and Northern Railway enters the re basin near its head, on the Gila River, and passes up the valley San Carlos River, a total distance of 5.75 miles in the reservo This railroad was built in the fall of 1898. A better location road, away from the river, was recommended by the locatin neer. It provided for the crossing of the neck of land betwe Gila and the San Carlos. The location of this line is indicated topography on the reservoir map (Pl. XXVII). The railroad c changed from its present location, beginning at a point 2 miles the Gila River bridge and crossing the Gila at that point, passi a divide on the point of land mentioned above at an elevation than 200 feet above the bed of the stream, crossing the San C miles above the San Carlos station, and joining the present line last-named point. The length of new construction would be 5 The roadway would cost about $8,000 per mile, or a total of $ The material for the roadbed would cost, approximately, $4,0 mile, but could be moved from the old location. There woul





CONTOUR MAP OF THE GROUNDS OF THE SAN CARLOS INDIAN AGENCY AND MILITARY POST, SHOWING LOCATION OF BUILDINGS.

al; building of adobe and military tank above it. *B*, adobe buildings occupied by the officers. *C*, frame gs used as barracks. *D*, adobe buildings used as stables. *E*, school grounds; buildings mainly of adobe. s or wigwams used by the Indian police. *G*, guardhouse. *H*, trader's store. *I*, stone warehouses. *J*, offices United States Indian agency; built of adobe. *K*, shops and stables built of stone.

ing of 4 miles in distance in the new line over the old, which should ıpensate for the moving. There would be two bridges to move, at approximate cost of $10,000.

'he Gila bridge contains thirty-three 16-foot bents and three small .ns. The San Carlos bridge has thirty-four 16-foot bents. The total t of moving this railroad has been estimated at $50,000. As all the terial for the construction of the dam that will be shipped to San rlos will have to pass over this railroad, including about 25,000 ·rels of cement, and as the railroad will be shortened 5 miles without y serious additional grade and removed from a valley of two torrential eams, it would seem that this change of location might be readily 'anged. The reason the railroad was placed in its present location s to enable it to reach the post and agency and secure that trade. ith the agency removed, there would no longer be the occasion for present location.

Estimate, San Carlos dam.

bble masonry, laid in concrete, 94,730 cubic yards, at $6	$568,380.00
NOTE.—With sand cement, at $4.63 per barrel, or $4.28 per cubic yard. (See Duryee's report.) This figure is based on half of the mass being large rock and half concrete.	
:avation foundation, pumping, etc	150,000.00
ımicircular tower, of concrete, 13,632 cubic feet, at 50 cents	6,816.00
wer, same diameter inside, 60 feet high, 4,238 cubic feet, at 50 cents	2,119.00
ower houses, including the semicircular base of concrete, at 750 each	1,500.00
nlets for towers, at $500 each	5,000.00
ılance valves, at $1,000 each	2,000.00
ılance valves, at $750 each	1,500.00
linear feet of footbridge, at $10	6,100.00
ıiles of railway, moved, at $10,000 per mile	50,000.00
v irrigation system above the Indian agency	20,000.00
nage to agency and post buildings	60,000.00
v water diversion tunnel	10,000.00
oden crib diversion dam at head of irrigation canal	20,000.00
	903,415.00
ıtingencies, 10 per cent	90,341.00
;ineering, 5 per cent	45,170.00
Total	1,038,926.00

otal number of acre-feet stored is 241,396, at a rate of $4.30 per acre-foot.

GUTHRIE RESERVOIR.

'he Guthrie reservoir site is situated in Graham County, Arizona, ›ut 30 miles northeast of the town of Solomonville, on the Gila ;er. The dam site shown on Pl. XXX is about 1 mile above the ronado Ranch House, in what is known as York Canyon. This ıpproximately 4 miles above Guthrie and 13 miles below Duncan. e canyon is about 2,000 feet long, opening both above and below into ıad valleys. The survey was made for a 140-foot dam, as a natural

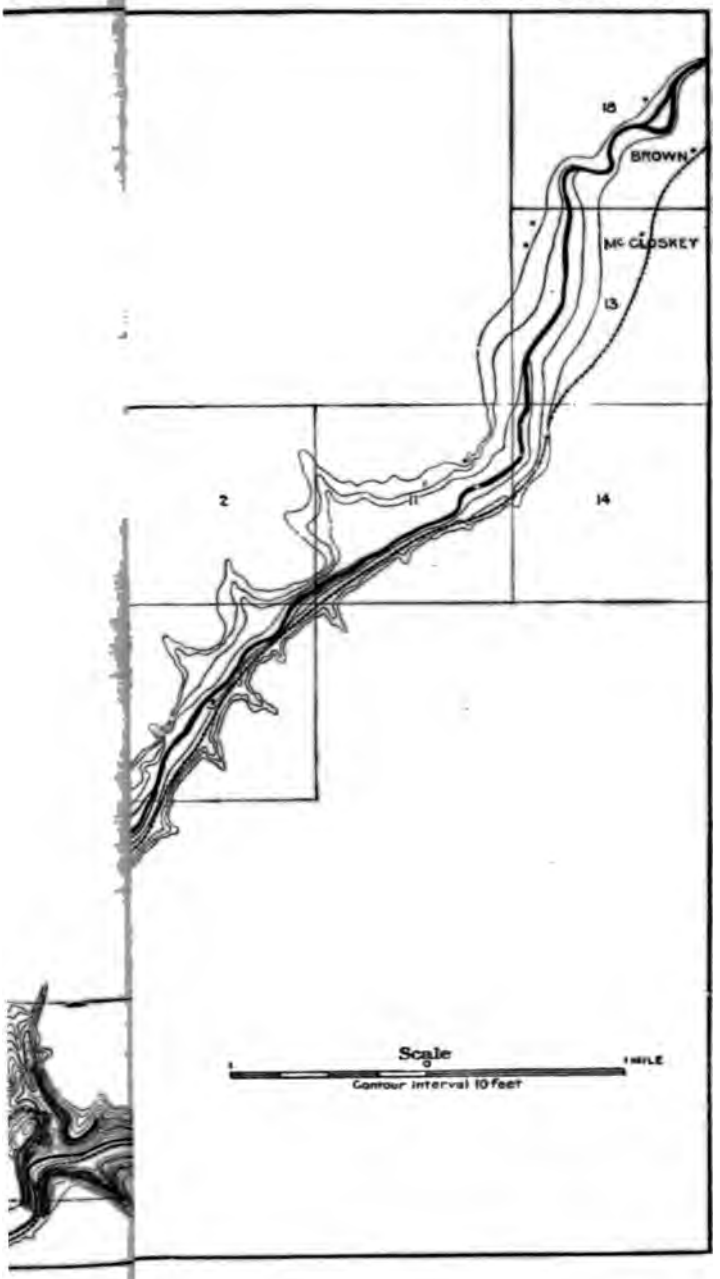
spillway occurs one-half mile east of the dam site, the lowest elevation of which is 130 feet. The main wagon road through the valley passes directly through this spillway. The opening varies from 200 to 300 feet in the bed of the canyon and from 800 to 900 feet in width at an elevation of 140 feet above the stream. The cliffs of the canyon are composed of volcanic rock, and quarries could be located at an elevation above the dam site. No borings for bed rock have been made at this point, because of the lack of funds, and also on account of its remoteness from other portions of the work. The walls of the canyon indicate varying conditions of lava flow. They are shattered, and in some instances there are strata of hard rock overlying cobbles and clay. It is not probable that the rock could be quarried in great quantities or in blocks, and it would be difficult to get good abutments. It has been exceedingly contorted and crushed at an elevation of about 40 feet above the bed of the river.

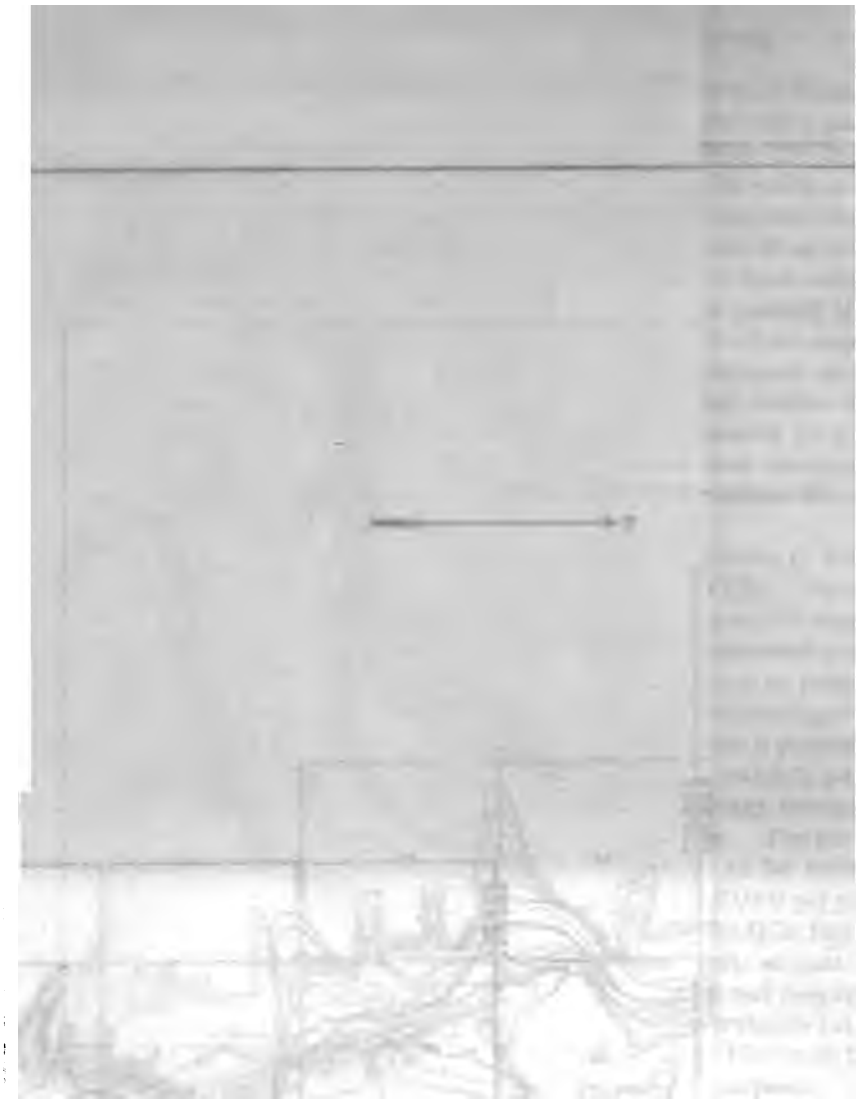
The survey of the reservoir site was made by Mr. Cyrus C. Babb, hydrographer, on a scale of 1 mile to 2½ inches (Pl. XXIX). The 140-foot contour runs within three-quarters of a mile of the town of Duncan. It is probable that the type of dam which would be constructed at this point, if one should be built, would be of a rock-fill type or possibly of earth. The basin of the reservoir contains no irrigated agricultural land, but it would appear to be possible to irrigate a portion of this valley. The New Mexico and Arizona Railroad, which is a narrow-gage road running to Morenci, Arizona, passes through the entire length of this reservoir site and through the dam site. The side of the reservoir site on which the railroad would have to be built is rough, and the cost of construction would be at least $20,000 per mile. Three large tributaries of the Gila—the San Carlos, the Gila Bonita, and the San Francisco—join the river below this point, so that the water supply would be considerably reduced. It was not necessary to prepare estimates on this dam site, but owing to its probable future value for irrigation purposes near Solomonville and Florence, it is recommended that the site be reserved for irrigation purposes. The capacities of this reservoir, with varying intervals, above the bed of the streams at the dam site are given in the following table:

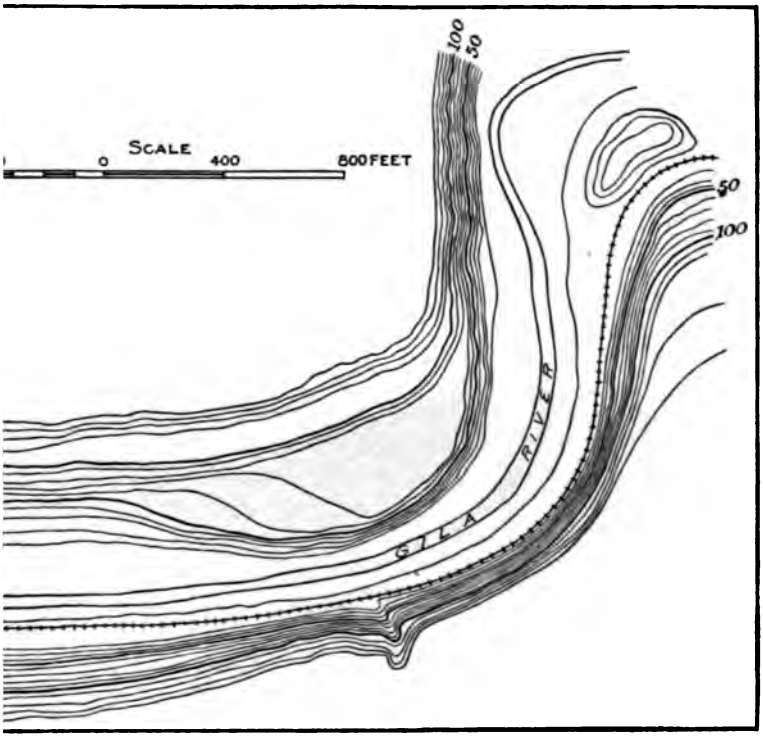
Table of capacities, Guthrie reservoir.

[Capacities calculated by averaging each two sections and multiplying by 10.]

Contour.	Area.	Capacity of each section.	Total capacity.	Contour.	Area.	Capacity of each section.	Total capacity.
	Acres.	*Acre-feet.*	*Acre-feet.*		*Acres.*	*Acre-feet.*	*Acre-feet.*
10	14	70	70	80	1,875	16,530	46,705
20	45	295	365	90	2,383	21,290	67,995
30	154	995	1,360	100	2,844	26,135	94,130
40	390	2,720	4,080	110	3,311	30,775	124,905
50	669	5,445	9,525	120	3,692	36,365	161,270
60	1,000	8,495	18,020	130	4,696	43,290	204,560
70	1,431	12,155	30,175	140	5,552	51,240	255,800


15
BROWN
McCLOSKEY
13
2
14
Scale
1 MILE
Contour interval 10 feet





CONTOUR MAP OF GUTHRIE DAM SITE.

QUEEN CREEK RESERVOIR.

Queen Creek rises in the mountains to the westward of the Silver King mining camp, in Pinal County, Arizona, and flows in a general southwesterly direction, leaving the mountains below a point known as Whitlow's ranch, approximately 18 miles north of the Buttes. In ordinary years it loses itself in the desert north of the Gila River Indian Reservation. The reservoir site was surveyed with a plane table to a height of 140 feet above the bed of the stream at the dam site and contoured in 10-foot intervals (Pl. XXXI). The following table gives the capacity of this reservoir with varying heights of dam:

Area and capacity of Queen Creek reservoir.

Contour.	Area.	Capacity.	Contour.	Area.	Capacity.	Contour.	Area.	Capacity.
	Acres.	*Acre-ft.*		*Acres.*	*Acre-ft.*		*Acres.*	*Acre-ft.*
2,060...	8	40	2,110	279	5,425	2,160	757	30,795
2,070...	22	190	2,120	356	8,600	2,170	894	39,050
2,080...	52	560	2,130	445	12,605	2,180	1,019	48,615
2,090...	112	1,380	2,140	538	17,520	2,190	1,091	50,665
2,100...	209	2,985	2,150	630	23,360	.....	.....	.....

A dam of the rock-fill type was estimated upon in 1895 to cost $221,000. The total area of the drainage is 142.5 square miles.

Observations on the discharge of Queen Creek were commenced in 1895, at the time of the first investigation for a water supply for the Gila River Indian Reservation. A gage rod was then placed and a gaging station established at Whitlow's ranch, at the dam site of the Queen Creek reservoir site. During the year 1896 an observer was employed and located at this station. At the time of the establishment of the station there was a slight permanent flow, averaging about 2 second-feet, which next year failed. The principal water supply of this creek consists of floods of one or two days' duration, occurring immediately after a rainfall in the basin. On this account, in order to obtain an accurate determination of the discharge, an observer has to be constantly located at the station to measure the discharge and to record its duration of flow. Such a system was employed during 1896 and until April, 1897.

The monthly discharge at this station for 1896 is published in the Eighteenth Annual Report of the United States Geological Survey, Part IV, page 295. The total discharge for the year was 10,887 acre-feet. The daily observations for 1897 are published in the Nineteenth Annual Report, Part IV, page 417. The floods were measured as they occurred, and it is assumed that they lasted twelve hours each. On this basis the total discharge to April 6, 1897, was 8,020 acre-feet.

The total discharge for the year has been estimated in the following manner, and is only roughly approximate. A rainfall record has been kept at Pinal ranch, within the drainage area, from 1895 to the pres-

ent date, inclusive. The total precipitation for 1897 was 23.23 inches. For the period from January to March, inclusive, during the time in which measurements of discharge on the creek were made, the precipitation was 14.21 inches. A proportion was, therefore, made—14.21 is to 23.23 as 8,020 is to total discharge for the year. Working out this proportion gives a total discharge of 13,110 acre-feet.

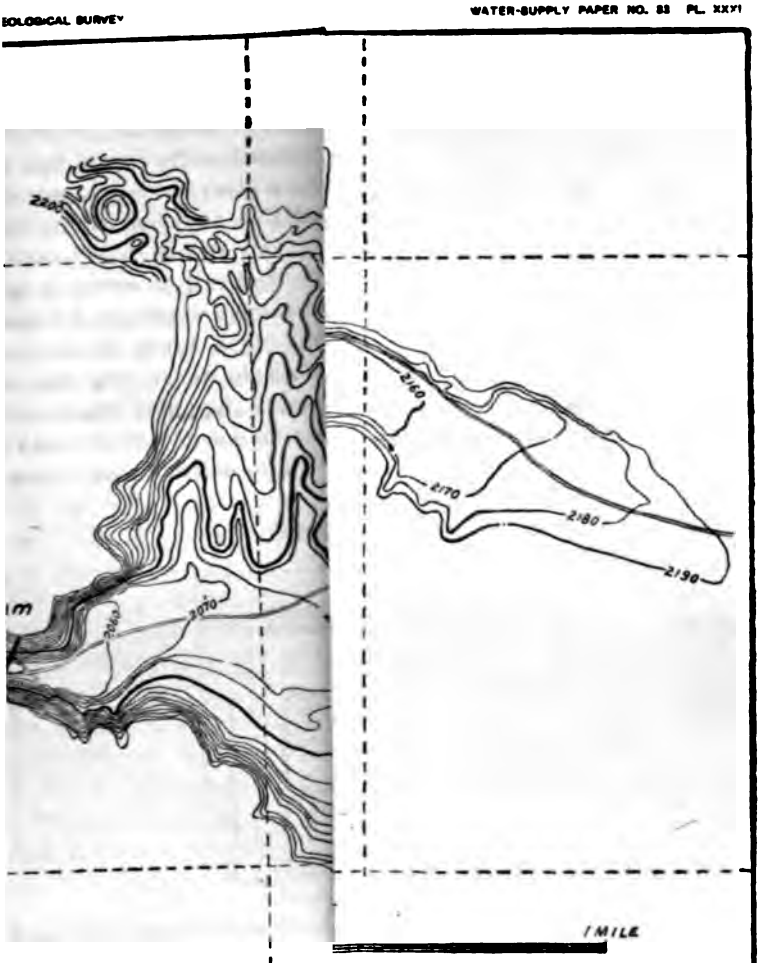
An observer was employed at this station for July, August, and September, 1898. He recorded the heights of floods on the gage rod as they occurred. From this record, in connection with the cross sections which were measured, an estimate of the discharge of the creek was made. These observations are reported in Water-Supply and Irrigation Paper No. 28 of the United States Geological Survey, page 132. The discharge for these three months has been computed as 5,140 acre-feet, including the one flood occurring in December of that year. The creek was reported dry from the 1st of March until the time the observer assumed his duties, and from September to the measured flood, December 18. One flood occurred, however, in January or February, 1898, of which no record was kept, but the quantity was not notably large. It is reported by people located in the basin that the year 1898 was characterized by an exceedingly small flow of the creek. The total discharge for the year is assumed as 6,000 acre-feet. It is probable this amount was not exceeded.

The old gaging station was reestablished in December, 1898, and an observer employed to record any floods occurring. Meter measurements were not made, but gage records were taken on both the original gage and a slope gage placed 431 feet above and referred to the same datum. Cross sections of each flood were measured. From this data the discharges of the creek were computed by means of the Kutter formula. From these computations for the period from January 1 to August 11, 1899, the discharge is found to be 12,527 acre-feet.

Summary, total annual discharge of Queen Creek at Whitlow's ranch, Arizona.

Year.	Acre-feet.
1896	10,887
1897	13,110
1898	6,000
1899, Jan. 1 to Aug. 11	12,527

As it has been shown that 10,875 acres, requiring 20,000 acre-feet of water, are needed at once for the Indians who are on or near the Gila River Indian Reservation, and as an ultimate consumption of 40,000 acre-feet is estimated as a possible future need and this amount accepted as the basis of this report, it is obvious that Queen Creek is not able to supply the full demand, either present or prospective.



·1, 10 feet

2. BABB in 1896

BED ROCK AT DAM SITE.

A diamond core drilling outfit was sent to Queen Creek on April 17, 1899, and the work was completed on May 20, 1899. It was found difficult to drive the pipe at this point, owing to the presence of numerous bowlders in the covering of the bed rock. The pipe was frequently bent and it was often found necessary to place dynamite in the hole, raise the pipe a few feet, and explode the powder before the pipe could be driven to bed rock. There were 11 holes put down, their relative location being shown on Pl. XXXII, *A*. The elevations at each of these is given in the list below. At a point on the figure marked "Gage" is the upper gage rod, its zero being at an elevation of 2,041.7 feet. At the point near this, marked "Iron," is the northwesterly iron gad, put at an elevation of 2,049.9 feet. Opposite this is the northeastern iron gad, at an elevation of 2,060.6 feet. At the point marked "B. M." is one of the bronze tablets of the Geological Survey, placed at an elevation of 2,055.1 feet.

Borings at Queen Creek.

Hole.	Surface elevation.	Bed-rock elevation.	Depth.	Depth bored into rock.
	Feet.	*Feet.*	*Feet.*	*Feet.*
1	2,050.0	2,013.0	37.0	7.5
2	2,051.4	2,017.4	34.0	3.0
3	2,053.4	2,027.4	29.0	6.0
4	2,050.6	2,018.6	32.0	4.0
5	2,049.7	2,021.4	28.3	6.2
6	2,050.5	2,011.0	39.5	4.2
7	2,049.5	2,017.5	32.5	7.0
8	2,050.2	2,015.2	35.0	7.0
9	2,050.5	2,022.3	28.2	3.0
10	2,050.2	2,007.7	42.5	1.5
11	2,047.3	2,023.8	23.5	5.5

There is a United States Geological Survey bronze bench-mark tablet on the left bank, in line with the upper row of holes, set in the rock about 5 feet above bed of stream. Elevation, 2,055.7 feet.

The bed rock was found to be a uniform, heavy, volcanic product, having a specific gravity of 2.49, or a weight of 155.5 pounds per cubic foot. Its strength to resist crushing was greater than the capacity of the testing machine. A core three-fourths of an inch in diameter would not crush under a pressure of 1 ton. Further description of the Queen Creek dam and reservoir site may be found between pages 43 and 52 of the report on the irrigation investigation for the benefit of the Pimas and other Indians on the Gila River Indian Reservation, Arizona, by Mr. Arthur P. Davis, hydrographer, in Senate Document No. 27, Fifty-fourth Congress, second session.

CEMENT.

By EDWARD DURYEE.

Investigations were made under instructions from Mr. J. B. Lippincott, in order to ascertain means of lessening the cost of Portland cement in the construction of dams on the Gila River in Arizona. Owing to the remoteness of these proposed dams from lines of transportation, the expense of bringing cement to the sites makes a notable addition to the cost over construction elsewhere, and it is therefore of great importance to reduce the quantity of cement to the smallest allowable amount.

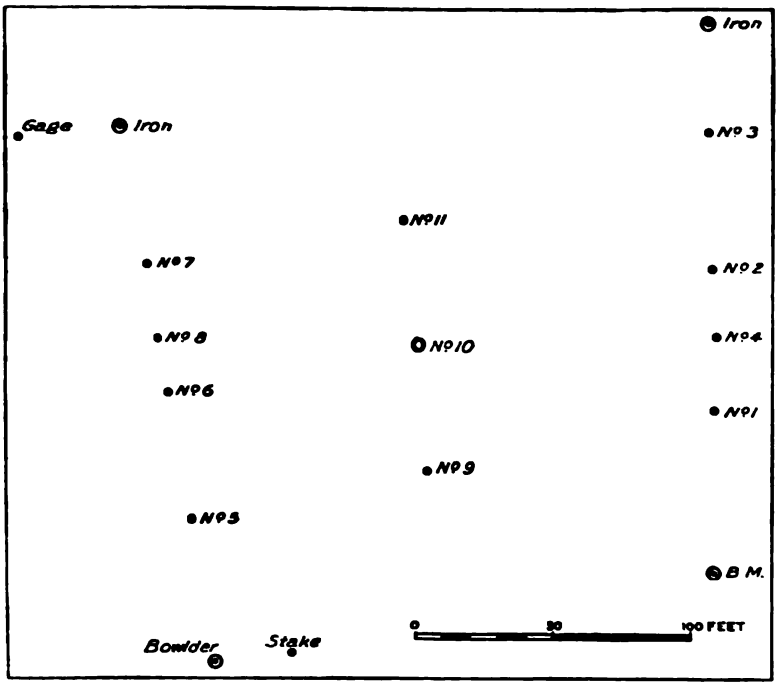
Portland cement is considered an essential element in the construction of dams subject to severe and sudden strains due to floods. It is valuable not only in giving great strength and homogeneity to the structure, but also because of the fact that exposure to moisture, which deteriorates many materials, serves to increase the strength of Portland-cement mortars. It is thus being largely used for this purpose. For example, the new dam under construction on the Nile at Assuan will require 3,000,000 barrels of Portland cement, costing, in round numbers, $12,000,000.

The investigation of cement for the Gila River dams has been along three lines: (1) To ascertain whether by unusually fine grinding of the cement its strength can be appreciably enhanced and the quantity correspondingly reduced; (2) whether it is feasible to use the rocks found at the dam sites for making a sand cement; (3) whether Portland cement can be economically made at these sites.

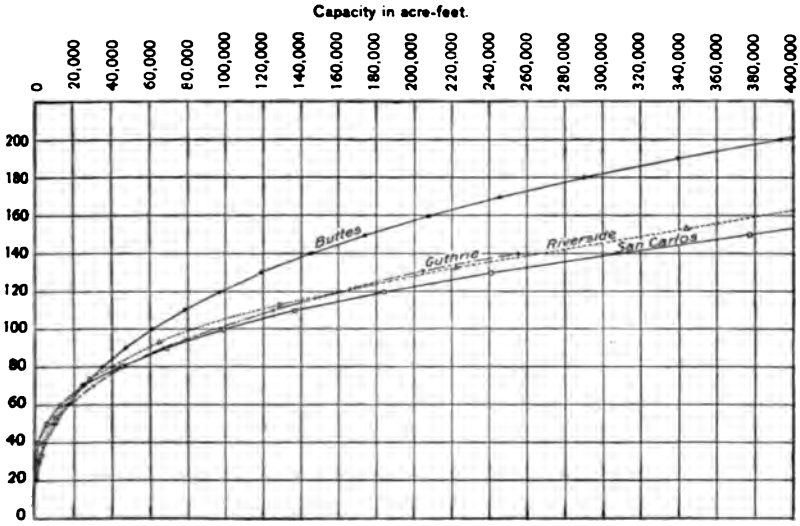
SAND CEMENT.

Sand cement is a term applied to a mixture of cement and sand ground together in a dry state to an impalpable powder. As a rule Portland cement and quartz sand are the materials thus used. This mixture is then used with ordinary sand and gravel, as in the customary practice. The proportion of pure cement is thus considerably reduced, but the strength and durability of the concrete has been found to be nearly as great as that made with the undiluted cement. The explanation offered for the remarkably good results obtained with sand cement when used with ordinary coarse sand is that the voids in the coarse sand are nearly filled with the finely ground sand. The grains are thus bonded together and to the coarse sand by the uniformly diffused particles of the fine cement. The amount of voids in the ordinary sand, in other words, is greatly reduced by the fine sand, fulfilling the requirement for a strong mortar that it is necessary to be of dense character, the grains being of such graduated size and so well mingled as to afford the maximum contact of the surfaces of the particles.

In sand-cement mortar the grains of sand are extremely minute,



A. LOCATION OF BORINGS AT QUEEN CREEK DAM SITE.



B. CAPACITY CURVES OF THE PROPOSED RESERVOIRS ON GILA RIVER, ARIZONA.

the mixture being so fine that only 5 per cent residue is left on a screen of 200 meshes to the linear inch or 40,000 meshes to the square inch. The great density thus obtained contributes to the impermeability to water and increases the compressive strength and load-bearing capacity, thus rendering the mass of value for constructing foundations, dams, and sea walls.

In the tests made in this investigation a rock known as pearlite, an acidic lava or rhyolite from the Buttes dam site, was used, and also samples of quartzite from the San Carlos dam site. These were chosen because of the abundance of these rocks at the localities named and their superior hardness. The Portland cement used was that manufactured at Colton, California, this being made nearest to the place where it will be used and being sold at a lower price than other Portland cement in the local market. All of the tests were made with the same sample of cement, portions of this being taken for the several mixtures with crushed pearlite and quartzite. The sand used with the foreign cement in making sand cement was clean beach sand from dunes along the coast.

TESTS OF SAND CEMENTS.

Results of the tests of the sand cements and comparisons with other mixtures are given in the following table. In each case the crushed pearlite was mixed with an equal weight of cement, and the mixture was ground in a mortar until it all passed through a screen having 200 meshes to the linear inch. The same method was pursued with the quartzite from San Carlos, thus making sand cements composed of equal parts of Portland cement and pulverized rock ground to an exceedingly fine condition.

The coarse sand used in making the mortar with the sand cement and with the pure (Portland) Colton cement was of the ordinary grade of fineness used for making cement tests. It was screened from ordinary gravel, all residue on the 20-mesh screen being rejected and all left on the 30-mesh screen being retained.

The briquettes for testing were made according to the specifications recommended by the American Society of Civil Engineers. After the briquettes were made they were kept under a damp cloth for twenty-four hours, then placed in vats of water, where they were left until the time for breaking arrived, namely, seven days or twenty-eight days. The fine grinding and diluting of the Portland cement with fine sand did not materially affect the time of hardening or setting. The beginning of the setting process of the ordinary Colton cement mortar, or initial setting, was thirty-three minutes, and the time of final setting was eighty-five minutes. This applies to samples Nos. 3, 4, and 9 of the following list. The corresponding periods for the sand cement were thirty and eighty minutes. The cement mortar continues to harden and increase in firmness for a year or longer.

Results of tests of Portland sand cements.

No.	Material.	Sand.	Portland cement to sand.	Fineness.			Water.	Strength.	
				50 mesh.	100 mesh.	200 mesh.		7 days.	28 days.
				Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Lbs.*	*Lbs.*
1	Colton and Butte pearlite, 1 to 1	2	1 to 5	0.00	0.00	0.00	10	80	300
2	Colton and San Carlos quartzite, 1 to 1	2	1 to 5	.00	.00	.00	10	90	345
3	Colton, regular	2	1 to 2	.42	7.20	33.20	10	170	395
4	do	3	1 to 3	.42	7.20	33.20	10	140	240
5	Colton, fine ground	2	1 to 2	.00	.00	(a)	12	370	465
6	do	3	1 to 3	.00	.00	(a)	12	170	260
7	Colton and Butte pearlite, 1 to 1	3	1 to 7	.00	.00	.00	10	75	155
8	Colton and San Carlos quartzite, 1 to 1	3	1 to 7	.00	.00	.00	10	55	185
9	Colton, regular	0	1 to 0	.42	7.20	33.20	18	615	660
10	Imported	0	1 to 0	.80	7.80	29.33	18	345	525
11	Imported and sand, 1 to 1	2	1 to 5	.00	.00	.00	10	115	190
12	do	2	1 to 5	.00	.00	(a)	10	125	185
13	do	3	1 to 7	.00	.00	(a)	10	55	90
14	do	3	1 to 7	.00	.00	.00	10	90	140
15	Imported, regular	2	1 to 2	.80	7.80	29.33	10	210	270
16	do	3	1 to 3	.80	7.80	29.33	10	120	175

a Some left on 200-mesh screen.

NOTE.—The above cement stood the boiling test for free lime satisfactorily.

Comparison of test No. 3 with No. 5, and of No. 4 with No. 6, shows that increased fineness of grinding very materially increases the strength and sand-carrying capacity of cements. The ordinary Colton cement of tests No. 3 and No. 4 was ground finer than commercial Portland is usually ground. Recent improvements in mills for grinding render possible a reduction in size of cement grains at a cost which is small when compared with the great increase in the value of the resulting material. Where the freight charges are high, as is the case at the locations under consideration, it is especially important to take advantage of this improvement, and there is no doubt that if the specifications call for a fineness such that only 1 per cent is to be left on a 100-mesh screen, the manufacturers will respond to the requirements. Engineering specifications have ordinarily allowed a residue of 5 per cent on a 50-mesh screen, although manufacturers have for some years permitted a residue of only 1 or 2 per cent on a 50-mesh screen.

CRUSHING TESTS.

In order to obtain the crushing strength of the various cements and concrete considered, two 1-inch cubes of each were broken. The results given are the averages of the crushing strength of the two cubes. The cubes were allowed to remain thirty days in water and then thirty days in the air.

Crushing tests of 1-inch cubes.

Character of mixture.	Water.	Average crushing strength.
	Per cent.	*Tons.*
Standard Colton cement	18	3.25
Colton cement, 1 part, and ordinary testing sand, 2 parts	8	1.75
Colton cement, 1 part, and marble sand, 2 parts	8	2.38

Crushing tests were also made of 6-inch cubes of concrete after these ad been immersed for thirty days in water. The portions of the mixure and the breaking strain in tons are given in the following table. n the mixture the proportions are given by volume and not by weight.

Crushing tests of 6-inch cubes.

Character of mixture.	Breaking strength.
	Tons.
Colton cement, 1 part; ordinary sand, 3 parts; pebbles from gravel, 6 parts	38
Colton cement, 1 part; sand, 3 parts; crushed marble, 6 parts	30
Colton cement, 1 part; sand, 2 parts; crushed marble, 5 parts	20

It is believed that concretes of approximately equal value can be btained by using cements in the following proportions, measured by olume:

Portland cement, 1; sand, 3; broken stone, 7.
Sand cement, 1; sand, 2; broken stone, 6.

COST OF SAND CEMENTS.

In the Portland-cement concrete made in the proportion of cement part, sand 3 parts, and broken stone 7 parts, it has been found that 70 pounds of cement will be required for a cubic yard of concrete. his, at 2.12 cents per pound, will cost $5.72 per cubic yard.

In the sand-cement concrete of the proportions 1 cement, 2 sand, nd 6 stone, 340 pounds of cement would be required for each cubic ard of concrete. This, at 1.2 cents per pound, would cost $4.08.

The saving in the cost of cement to be effected by using sand cement nstead of the Colton Portland will be the difference between $5.72 nd $4.08, or $1.64 per cubic yard of this concrete entering into the onstruction of the dam. From the total saving thus realized should, owever, be deducted the cost of the plant required for grinding the and cement.

Concrete blocks composed of the above proportions were crushed at McGill University in 1898, with the following results:[1]

Sand cement, 1; sand, 2; broken stone, 6; water, 30 per cent.

Weight per cubic foot, 154 pounds. Crushing load, in pounds per square inch: Seven days, 521 pounds; twenty-eight days, 639 pounds; sixty days, 670 pounds.

A concrete of German Portland of the proportions of 1 cement, 2 sand, 6 broken stone, and 30 per cent water stood a load of 728 pounds per square inch in twenty-eight days, and one of the same proportions made from English Portland stood 698 pounds in twenty-eight days.

Tests for crushing strength on 6-inch cubes of concrete, made of 1 part sand cement, 2 sand, and 3 parts gravel, were made on concrete that was taken from the bucket just as it was ready to be laid in the foundation of the Cathedral of St. John the Divine, in New York City. Each result is the average of the crushing strength of four separate cubes, made under exactly the same conditions at different periods:

	Pounds.
7 days old crushed at	77,168
14 days old crushed at	83,235
30 days old crushed at	92,465

Approximate cost of plant for making sand cement; capacity, 240 barrels per twenty-four hours.

Crusher (required also for crushing rock for concrete)	$2,000.00
Mill for coarse grinding	2,000.00
Tube mill for finishing	2,500.00
Engine and boiler	1,500.00
Setting up machinery	1,000.00
Buildings and bins	1,000.00
Total	10,000.00
Cost of mill, per barrel of cement	.30
Add for concrete making a power mixing machine	1,500.00

In making concrete, if a good quality of stone be used, and the rock be crushed so as to be well graduated as to sizes, thus securing a minimum of voids, the compressive strength of the concrete increases as the proportion of stone increases and as the volume of voids between the stone decreases, and decreases as the proportion of sand in the mortar increases. The rule, therefore, holds that, to secure the greatest strength, mix the maximum quantity of stone with a minimum of sand mortar sufficient to bond the stone together, the sand mortar being rich in cement. An extensive bed of exceptionally good sand for mortar was found near the Buttes, the grains graduating in size from very small to large sizes. It shows only 35 per cent of voids, while the standard cement-testing sand used in laboratories has 45 per cent of voids.

[1] From Canadian Architect and Builder, 1899.

A large tube mill will grind 10 barrels of sand cement per hour to ıe requisite degree of fineness, at an estimated cost of 20 cents per ırrel. The cost of power for grinding is calculated at 3 cents per ɔrsepower per hour at the dam site.

Cost of sand cement with Portland cement at $8 per barrel.

ne-half barrel Portland	$4.00
ne-half barrel crushed and coarse-ground quartzite	.18
rinding same in a tube mill	.20
oyalty on account of sand-cement patent	.05
Total cost of sand cement per barrel (375 pounds)	4.43

The cost of sand cement per pound, quartzite being used as the ɔurce of the sand cement, would therefore be 1.2 cents.

The cost of the mill per barrel of cement, 20 cents, is not included ı the above.

It is estimated that the cost per barrel of Colton Portland cement, ɜlivered at the dam site will be $8. This, for 375 pounds weight ɜment, would make the cement cost 2.12 cents per pound.

USE OF ROCKS AT THE DAM SITES.

For the purpose of ascertaining whether the rocks at the dam sites ɔuld be used in the manufacture of Portland cement the localities ere visited and samples were obtained of those rocks which occurred ı sufficient quantities to furnish a supply necessary for manufactur-ıg the large amounts of cement needed. In looking for the raw ıaterials it must be borne in mind that, chemically considered, Port-ınd cement consists of a compound of tricalcium silicate and dical-ium aluminate, accompanied by small percentages of ferrate and ulphate of lime and traces of alkalies. It is made by grinding and ırning together either natural or artificial mixtures of carbonate of ime and silicate of alumina. Limestones, chalks, or marls usually urnish the carbonate of lime, and clays are the ordinary source of he alumina and silica. The mixtures are burned at a high tempera-ure to a blackish clinker of a semivitrified character. After cooling, his clinker is reduced by grinding to an impalpable powder, in which orm it is known by the generic name of Portland cement.

ROCKS AT RIVERSIDE DAM SITE.

Limestone (No. 3 in the following table) was obtained near River-de, on the road to the Pioneer mill, where it is found in large quan-ties along the roadside. The rhyolite (No. 4 in the following table) as found 2 miles south of the Riverside site. It offered the closest pproach to a suitable silicate of alumina that could be found.

The source of elements of silica and alumina in the crude material should, however, be sedimentary in character, not igneous or metamorphic. The analysis justified a trial mixture, and therefore one was calculated and made, but on burning the materials failed to effect the requisite combination for a Portland cement. Too large a percentage of the silica was in the free or uncombined condition. Fuel was not to be found near the Riverside site, and the manufacture of cement at this place is considered impracticable.

ROCKS AT SAN CARLOS DAM SITE.

The limestone from San Carlos site (No. 2 in the following table) was found to be admirably adapted to the purpose of the dam construction on account of its good specific gravity (which was 2.7), freedom from flaws, and siliceous character. It occurs in vast quantities, forming the abutments at the dam site. It forms bluffs, extending for several hundred feet, well located for quarrying. Large masses may be embedded in the concrete, care being taken that they be laid irregularly in the mass of the dam, and are well placed so as to bond into a monolith.

Analyses of rocks from the vicinity of the dam sites.

[Chemical composition, in percentages.]

No.	Name.	Color.	Locality.	Sp. gr.	Carbonate of lime, $CaCO_3$.	Carbonate of magnesia.	Silica (SiO_2).	Alumina and ferric oxide.	Moisture.	Lime per cent in the carbonate of lime.
1	Limestone	Gray	San Carlos	.....	96.65	0.00	1.4	1.3	0.65	54.124
2	do	Pink	do	2.709	55.92	31.00	3.7	6.0	1.00	31.315
3	do	Blue	Riverside	.....	93.10	0.00	4.7	1.4	.....	52.136
4	Rhyolite	White	do	1.541	9.60	.....	60.9	12.6	16.90	5.376
5	do	Pearl	Buttes	2.361	.....	.....	.....	.....	.....	.....
6	Limestone	Blue	Queen Creek *a*	2.81	90.10	0.00	4.1	5.8	.....	.....
7	do	Gray	do	2.678	55.50	0.00	34.6	1.3	.....	31.08

a From about 1½ mile above dam site.

The analysis of the gray or bluish limestone (No. 1 in the above table) shows from its freedom from magnesia and the small percentage of free silica that it is possible to make a Portland cement with it, provided a suitable clay can be found to furnish the requisite elements of silica, alumina, and ferric oxide.

FUEL.

An extensive but undeveloped deposit of bituminous coal is located about 17 miles from the San Carlos dam site. There is a wagon trail to within about 6 miles of the coal beds, but after leaving the wagon trail the only means of access was found to be a bridle path over the

hills. About ten years ago numerous prospectors' locations were made in the district, and shafts were sunk at a sufficient number of localities to prove the deposit to be of considerable extent. Most of the shafts have become filled with débris, but several were entered to depths of 15 to 30 feet. They showed the body of coal to be in beds having a dip of about 60°, the beds being from 5 to 10 feet in thickness, not of solid fuel, but showing seams of good coal interlaid with seams of slate and waste. In the bottom of the deepest shafts was found a good body of coal in a solid bed perhaps 5 feet thick. It was reported that at the time the prospecting was done on the claims some 30 tons were transported by wagons to the Southern Pacific Railroad and used in the locomotives, but that the cost of mining and transporting it to the railroad, with the crude means available at the time, was about $20 per ton.

Cement could be burned with the coal. The right to mine the coal for the use of the Government in this work could be secured readily and at a nominal cost. The cost of mining and transportation to San Carlos would, however, be high. In general practice 120 pounds of coal dust are used in burning 1 barrel of Portland cement.

Taking as a basis coal delivered at the dam site at $10 per ton, limestone at 40 cents per ton, and clay at $1.25 per ton, the cost of manufacturing Portland cement at the dam site would approximate $2.75 per barrel. The cost of erecting a plant with an output of 300 barrels of cement every twenty-four hours would be $75,000. Supposing the amount of cement to be required in the construction of the dam to be 50,000 barrels, the cost per barrel, if made at the site, would be approximately as follows: First cost of plant, $75,000; cost of manufacturing 50,000 barrels, at $2.75, $137,500; total cost, $212,500; cost per barrel, $4.25.

With reference to the degree of reliability to be placed upon Portland cement made in new localities, it may be said that the manufacture of this material has been put upon a scientific basis, such that the manufacturing chemist can predict the grade of cement to be made from the given materials and, by means of analyses of various rocks, can calculate suitable mixtures to produce the required result. The uniform system of testing cements recommended by the American Society of Civil Engineers affords a reliable means of determining the intrinsic merits of the product. The old method of buying cements on the reputation of the maker has been succeeded by tests for determining the actual value. Portland cements of American make are being extensively manufactured and are of equal or even superior quality to the foreign-made cements. During the year 1899 it is estimated that 6,000,000 barrels of Portland cement have been used, of which four-fifths were of home manufacture. In spite of this fact, on account of the failure to find suitable clays at the various

localities and also the difficulty of obtaining fuel, it is impracticable to manufacture Portland cement at the dam sites.

It is important, if Portland cement is used at the localities under consideration, that the specifications should require it to be ground so fine that not over 1 per cent residue shall remain on a 100-mesh screen.

Reliable sand cement can be made from the quartzite at San Carlos or the pearlite at the Buttes dam site by grinding with Colton (Portland) cement. A saving will result at the San Carlos dam site of $1.64 per cubic yard by making sand cement on the ground, this being exclusive of the cost of the plant for grinding.

IRRIGABLE LANDS.

The location where the water which is impounded in the reservoir sites on the Gila River would be used is primarily on the Gila River Indian Reservation, which has been described in previous pages of this report, and which contains 357,120 acres of land, the greater portion being irrigable. South of this Indian reservation, intervening between the Southern Pacific Company's railroad and the point where the Gila River leaves the mountains, there are many thousand acres of high-grade agricultural land suitable for irrigation. The climate is adapted to the raising of diversified crops, the grade of the country is uniform and suitable for the application of water, and the soil is exceedingly fertile. The river, which carries a large amount of sediment containing many fertilizing materials, will keep these lands in a state of continuous productiveness. Without water this land is a desert and has no value. That it is of no tangible value in its present condition is proved by the fact that many thousands of acres which have been taken up at previous times under the desert-land act and homestead laws have been permitted to revert to the Government before title was perfected by the settler, even after expenditures had been made on the land.

An examination was made of the records of the United States land office at Tucson to determine what portion of this area outside of the reservation remains public domain. The area in the valley of the Gila between Dudleyville and Riverside was also inspected, as this valley should be segregated for reservoir purposes, and in case of the construction of a reservoir at San Carlos a portion of its water could be used for irrigation in this valley. Nineteen townships were examined, and it was found that 389,211 acres therein are still public domain and that 52,162 acres, lying mostly under the Florence canal—which canal has a very deficient water right—is held in private ownership. There is, therefore, three times the area of irrigable land that can be served on the Indian reservation alone and three times the area of public land off the reservation that can be supplied.

YORK CANYON ON GILA RIVER AT GUTHRIE DAM SITE.

Public and private lands in the vicinity of Florence, Arizona.

Location.	Acres.	
	Government.	Private.
T. 4 S., R. 10 E	18,400	4,640
T. 4 S., R. 11 E	22,320	320
T. 4 S., R. 14 E	21,600	1,440
T. 5 S., R. 5 E	23,040	.....
T. 5 S., R. 6 E	23,040	.....
T. 5 S., R. 7 E	22,880	160
T. 5 S., R. 8 E	15,760	7,280
T. 5 S., R. 9 E	13,080	9,960
T. 5 S., R. 10 E	23,040	.....
T. 5 S., R. 14 E	22,960	80
T. 5 S., R. 15 E	21,000	2,040
T. 6 S., R. 5 E	17,840	5,200
T. 6 S., R. 6 E	12,800	10,240
T. 6 S., R. 7 E	19,440	3,600
T. 6 S., R. 8 E	21,732.06	3,116
T. 6 S., R. 9 E	24,359.26	486.26
T. 7 S., R. 6 E	19,800	3,240
T. 7 S., R. 7 E	22,680	360
T. 7 S., R. 8 E	23,040	.....
Total	389,211.32	52,162.26

DISTRIBUTION CANALS.

t is not the purpose of this report to definitely locate any canal line oss these lands. The construction would be entirely in earth and eedingly simple. The building of these canals could be readily lertaken by the settlers and by the Indians. The canal line to the lian reservation would be uniformly in smooth country and with earth section. A topographic map on a scale of 2 inches to the e, with contour intervals of 10 feet, has been made of a portion of se valley lands. This map demonstrates the feasibility of building se canals. The Florence Canal, which diverts its water at practi- y the same point where diversions of reservoir water would occur, s through the irrigable area under consideration and still further onstrates the feasibility and the practicability of the building of canals wherever circumstances may require.

ORGANIZATION OF IRRIGATION DISTRICT.

is recommended, in case of the construction of any of these rvoirs, that there be appointed a Federal commission to consider organization under Federal laws of an irrigation district which include the lands that would be irrigated under this system. This rict should be organized with proper officials to handle locally the ision and the distribution of the water and for the construction of delivery canals. The preparation of a code of laws for the opera- of this district would be of great importance and should be under- en jointly by members of the engineering and legal professions.

SUMMARY.

1. The available records of the discharge of Queen Creek at Whitlow's ranch indicates that this stream would not afford a sufficient and reliable water supply for the irrigation of an area as large as is required for the relief of the Indians on the Gila River Indian Reservation.

2. Because of the large amount of annual discharge of water by the Gila River and the high percentage of silt which it contains, it is not advisable to construct a reservoir of small capacity on this stream on account of the rapidity with which it would fill with silt.

3. In case of the construction of any of the dams on the Gila River the cost of putting the foundations down to bed rock is one of the principal elements of expense. This cost would be almost as large if a small dam was built as in the case of a large one.

4. The greatest economy to the Government, whether the relief of the Indian alone is considered, or the general development of the arid lands in the neighborhood of the reservation is taken as a basis, lies in the construction of a large reservoir. It is shown that the Government can build such a large reservoir, give water to the Indians without charging them for it, and sell the remainder of the water impounded at such figure as would rapidly return all the original investment made by the Federal authorities.

5. In the event of the construction of a large dam there will be built up in the valley of the Gila River, where a desert now exists, a community of fully 40,000 souls, and the creation of many million dollars of taxable wealth without permanent outlay on the part of the Government.

6. The cost per acre-foot of storage capacity of the dams as planned in this report at the three principal reservoir sites upon which estimates have been made is as follows:

Cost per acre-foot of water stored.

Location.	Amount.	Cost per acre-foot.
	Acre-feet.	
The Buttes	174,040	$15.19
Riverside	221,138	9.01
San Carlos	241,396	4.30

From this it will be seen that the cost of storing water at the Buttes per acre-foot is 3.5 times the cost at San Carlos, and that the cost at Riverside is 2.1 times the cost at San Carlos.

The capacity of the reservoir, the character of the foundations at the dam site, the conservative and well-known type of dam planned,

› economy of construction all point to the selection of the San reservoir site as the place for the construction of the dam.

aps the most notable result of this investigation of the water of the Gila River has been the discovery of three large reser- es the existence of which heretofore has been unknown. They › Riverside, the San Carlos, and the Guthrie sites. The rela- pacities of these are shown graphically on Pl. XXXII, *B*.

argument in favor of the construction of a reservoir for the › of the waters of the Gila River by the United States Govern- › stronger, perhaps, than for any other project in the country. ne Government has expended large sums of money for the ıction of irrigation on the Indian reservations where it is l to educate the Indian into agricultural habits as a means of ilization. This is a well-established and wise public policy, s already been productive of much good, but is always in the of an experiment, and more or less difficulty and uncertainty ıdant upon the attempt to induce the Indians to accept this f livelihood. In the present case we have a tribe of Indians ,ve for centuries been engaged in agriculture by irrigation, and ere until recently the only successful irrigators in Arizona. Indians have been deprived of their water supply through the of the white man, directly encouraged by the United States ıment. It is an imperative obligation of honor that their sup- ›uld be restored to them, and the only practical means of this tion is by storage on the Gila River. In addition to this, there out the certainty that unless this is done these Indians will ade from a condition of industry and prosperity to one of men- y and vice. Instead of an uncertain possibility of elevating a tribe, we are confronted with the necessity of preventing the ›tion of a civilization already attained.

is practically certain that the storage of the Gila waters will ›e accomplished by private or corporate enterprise for three ›: (1) The direct financial returns are not sufficient to induce ;e an investment of private capital; (2) the unquestionable ght of the Indians to a large quantity of the water of the Gila River be a perpetual cloud upon the title to the water in the hands rivate corporation; and (3) the land to be benefited being in public ownership, there is no means under present laws by a private company could realize the full benefit of their ements.

rizona being a Territory, the water right is entirely under na- jurisdiction; the only material private lien on the right is the f the Indians, who are wards of the Government, and this is ally a Government right. The objection applicable in some of tes, that the jurisdiction of water rights is entirely in the hands State and would produce a conflict of authority, does not apply

4. The Government, being the owner of more land under the ca than can ever be watered by it, can entirely control the appropria of the values which will be created by the construction of a reser and can entirely recoup itself for all expenses incurred, and thus charge its obligations of honor with no expenditure except the u zation of its own natural resources. It is not a proposition for Government to expend money for the benefit of private individ nor of any particular section, and hence is not comparable with ri and harbor improvements, although the general benefits are so c parable, as homes will be furnished at low rates to thousands of ind trious people, who will come from all parts of the country, and a bidding desert will be transformed into a rich oasis and a large c munity will be thus practically added to the domain of the Uni States.

5. Gila River rises in New Mexico. As the main body of the ba is in Arizona, inter-State complications might arise in the futur case the reservoir were constructed by private or local enterpr With these questions the National Government only is competen cope. Thus, from all points of view there is every reason why reservoir should be constructed by the National Government and reason why it should not, while it is not only impracticable but nently inadvisable for private enterprise to carry out the project.

6. Owing to the erratic nature of the Gila River less than 3 per of its water near Florence is now being used for irrigation, and areas now irrigated suffer intensely from summer droughts.

Financial summary of results.

Total water supply to be delivered to the point of diversion from San Carlos reservoir for irrigation each year ..... acre-feet..	24
Ultimate requirement for Indians ..... do....	4
Remainder available for irrigation of public domain or private lands ..... acre-feet..	20
Assume a duty of water of 2 acre-feet or 24 inches in depth used each year on each irrigated acre; this would permit the irrigation of lands outside the reservation to the extent of ..... acres..	10
There are 389,211 acres of arid public land in the district to be supplied from this system. Assume that the water is given to the Indians without cost to the Government and that these 100,698 acres must pay the total cost of the works, then the necessary charge per acre for the remaining water rights to be sold would be ..... It is believed that the public lands with this water right could, at this rate, be sold within a year.	$1
If 3,000 Indians have to be fed by the Government at a cost per ration per day of 10 cents, the annual expenses would be	$109
The capitalization of $109,500 at 4 per cent would represent the practical permanent expense of feeding these tribes. This is equivalent to a permanent Government debt, which would be liquidated by this construction, of	$2,737

The value of the 100,698 acres of irrigated public lands that would be taxable would be $50 per acre, or a total of	$5,034,900
The saving, without expense to the Government, by irrigation of 20,000 acres of lands belonging to the Indians has been shown to be	2,737,500
Total increase in value, without public expense	7,772,400

There will also be a large increase in value of taxable town property, not estimated upon.

RECOMMENDATIONS.

1. Immediately withdraw from entry all the lands that may be irrigated from this source of supply pending further action by Congress on this matter.

2. Segregate all the reservoir sites on the Gila River that may be used for the irrigation of these lands. The Buttes and Queen Creek reservoir sites have already been segregated for this purpose. The Riverside, San Carlos, and Guthrie reservoirs should also be set aside.

3. Maintain observations on the Gila River

4. Construct the San Carlos dam.

5. Give the Indians the water which they require without charge, the Government to recoup itself for all expenditures from the sale of the remaining water rights.

6. Form a Federal irrigation district for the division of the water, which is to be delivered to the head of the irrigation canals, for the construction of these canals, and for the general administration of the district.

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DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 34

GEOLOGY AND WATER RESOURCES OF A PORTION OF SOUTHEASTERN SOUTH DAKOTA.—TODD

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

IRRIGATION REPORTS.

The following list contains titles and brief descriptions of the principal reports relating to water supply and irrigation prepared by the United States Geological Survey since 1888:

1888.

First Annual Report of the United States Irrigation Survey, 1888; octavo, 159 pp.

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, a geological report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and report of work done during 1888.

1889.

Second Annual Report of the United States Irrigation Survey, 1889; octavo, 301 pp.

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889-90. Contains a description of the hydrographic of the arid region and of the engineering operations carried on by the Irrigation Survey during 1889, and also the statement of the relation of the Survey to the United Commission on Irrigation, and other reports concerning the geography of irrigation companies. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1890; octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890-91. Contains "Report upon the irrigation and storage of mountain water during the fiscal year ended June 30, 1890," by A. F. Ticknor; "Hydrography of the arid regions," by F. H. Newell; "Irrigation in Idaho," by Herbert M. Wilson. Illustrated by 41 plates and 194 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell; quarto.

No. 30, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No. 178, Irrigation in Oregon; No. 189, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 25, September 9, 1892; quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a resume of the water-supply and a description of irrigation by artesian wells. Illustrated by colored maps showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-92, Part III, Irrigation, 1893; octavo, 438 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American irrigation engineering," and "Engineering results of the Irrigation Survey," by Herbert M. Wilson; "Construction of topographic maps and selection and survey of reservoir sites," by J. B. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, 1893; octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 289 pp.

Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of irrigation wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical conditions and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892-93, in two parts; Part II, Accompanying papers, 1894; octavo, 697 pp.

Consists papers on "Public waters of the eastern United States," by W. J. McGee; "Mineral mineral waters of the United States," by A. C. Peale; and "Results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 34

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

J. C. Branner

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGY AND WATER RESOURCES

OF A PORTION OF

THE EASTERN SOUTH DAKOTA

BY

JAMES EDWARD TODD

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

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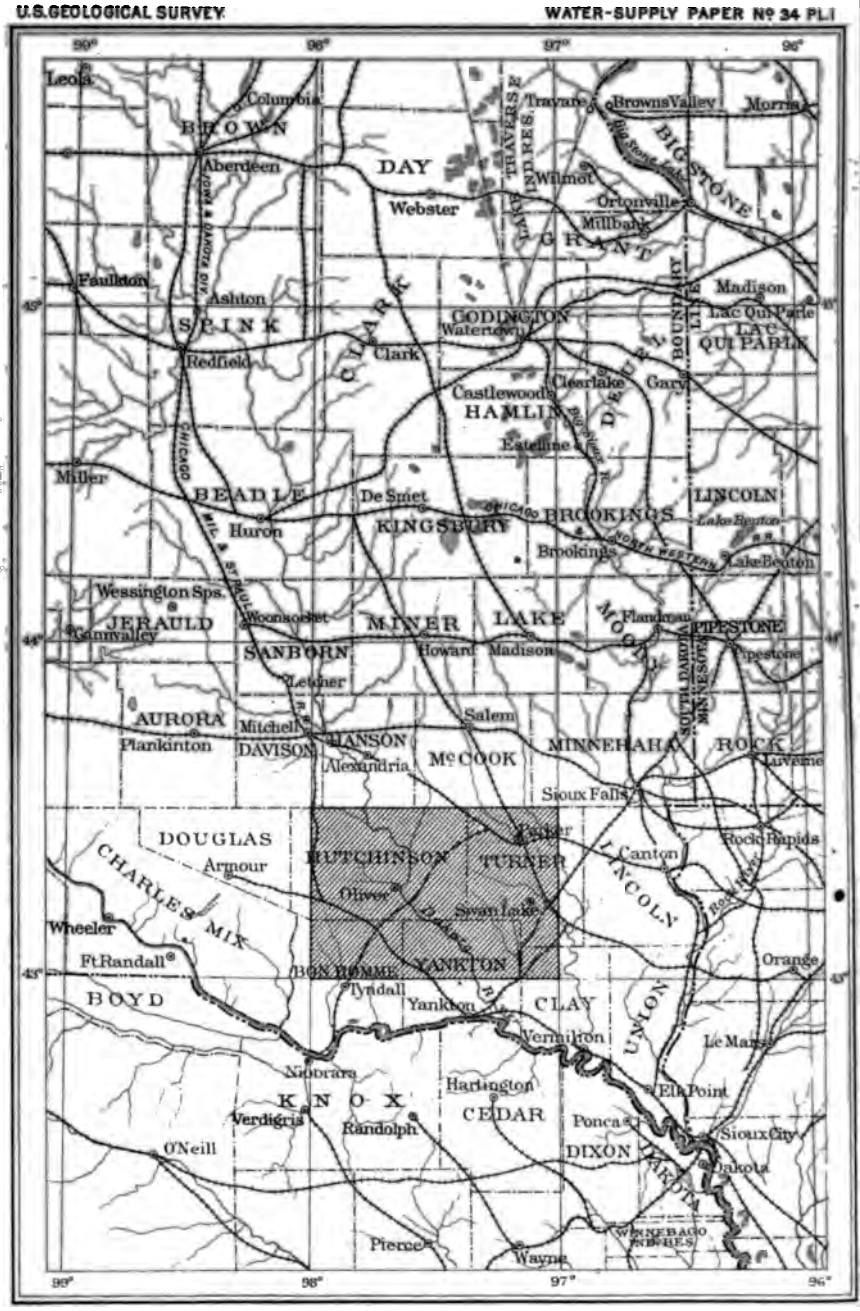
DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, February 15, 1900.

SIR: I have the honor to transmit herewith a manuscript giving the results of investigations of underground waters of a portion of southeastern South Dakota, prepared by Prof. James E. Todd, and to recommend that it be printed in the series of Water-Supply and Irrigation Papers.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.



INDEX MAP OF EASTERN SOUTH DAKOTA

Showing area under consideration

BY J. E. TODD 1899.

Scale

25 0 25 50 MILES

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GEOLOGY AND WATER RESOURCES OF A PORTION OF SOUTHEASTERN SOUTH DAKOTA.

By JAMES E. TODD.

LOCATION OF REGION.

The area to which this paper relates is represented on the Olivet and Parker sheets of the Topographic Atlas of the United States, published by the United States Geological Survey.[1] It occupies large portions of Turner and Hutchinson counties, and small portions of Bonhomme, Yankton, and Clay counties, South Dakota. It is especially instructive from the fact that it includes typical areas of the valleys of James and Vermilion rivers, and Turkey Ridge, which forms a portion of the divide between the two streams. Moreover, it exhibits characteristic features of two kinds of artesian supply, viz, that from the Dakota sandstone, and that from the sands underlying the drift. It also exhibits plainly the typical conditions of most forms of shallow wells, as well as the tubular wells common to the eastern portion of South Dakota. The region for the greater part is prairie and rarely so rough as to be unfavorable for ordinary agriculture. It includes wider ranges of altitude than most areas of similar extent in the Mississippi Valley; in the immediate valleys of Vermilion River, Clay Creek, and James River the surface is not over 1,180 feet above the sea, while in the northern culmination of Turkey Ridge it reaches 1,750 feet, and in the southwestern portion of the region it attains an altitude of 1,650 feet, which is considerably below the higher points of the Choteau Creek Hills a little farther west.

GENERAL GEOLOGY.

Nearly the whole surface of the area is covered with glacial drift. The exceptions are the alluvial flats in the larger valleys, and scattered exposures of older rocks occurring mainly along the sides of the canyons in the southern part of Turkey Ridge and in the bottoms of the

[1] These sheets may be procured at 5 cents each by addressing The Director, United States Geological Survey, Washington, D. C.

river channels. The strata lie nearly horizontal everywhere. No folds, faults, or igneous outflows have been discovered. Frequent borings have been made to a depth of 200 or 300 feet in obtaining wells, and a few have been sunk to 600 or 700 feet. These have furnished important facts concerning the position of strata below the surface.

ALGONKIAN.

SIOUX QUARTZITE.

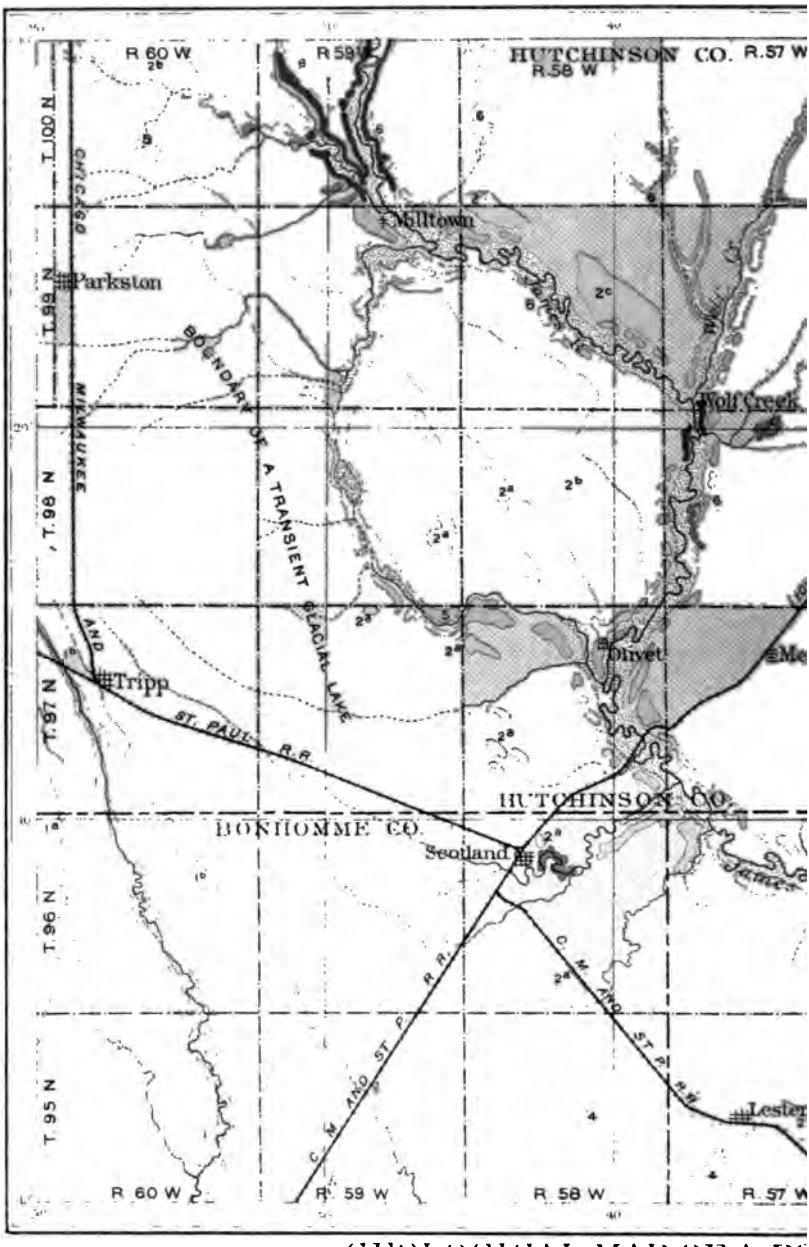
The oldest rock exposed in natural outcrops or by borings is the Sioux quartzite, a name given by Dr. C. A. White, when State geologist of Iowa. Exposures are found at a number of points along the East Fork of Vermilion River from the north line of Turner County to the vicinity of Parker, their location being indicated on Pl. III. Borings some distance from these exposures have shown that this formation is "bed rock," and the depth to its surface is indicated upon the map (Pl. IV). The rock is frequently called Sioux Falls "granite," from the extensive exposures and numerous quarries in the vicinity of Sioux Falls. It is for the most part a red or purplish quartzite of intensely compact and durable character, and is susceptible of a fine polish. It lies in strata which dip generally to the north at an angle of 3° to 5°. In sec. 8, T. 100 N., R. 53 W., it is in layers which are generally not more than 6 inches in thickness. East of Parker it is more massive, and the layers are 2 or 3 feet in thickness. No trace of slate or pipestone has been found in any of these exposures. No fossils have been noted in the formation anywhere, except some small lingulæ found by Prof. N. H. Winchell near Pipestone, Minnesota.[1] This formation is generally referred to the Algonkian. Its thickness has not been determined. At Sioux Falls a boring 500 feet deep revealed no important difference in the character of the rock.

THE PALEOZOIC GAP.

In this region there are no traces of Paleozoic formations nor of the Triassic and Jurassic of Mesozoic time. The surface of the Sioux quartzite shows marks of long erosion at an elevation of several hundred feet above sea level. The nearest occurrence of Paleozoic rock that has been discovered is in the borings at Ponca, Nebraska, and Sioux City, Iowa. While the mountain masses of the Appalachian region and the extensive coal fields of the eastern part of the Mississippi Valley were forming this area was probably a barren mountainous region. It is possible that soils and vegetations which may have extended over it were removed by the advance of the sea during Cretaceous time. At any rate, no traces of soil are now found upon

[1] Sixteenth Ann. Rept. Geol. Nat. Hist. Survey Minnesota.

U S GEOLOGICAL SURVEY



GEOLOGICAL MAP OF A PO

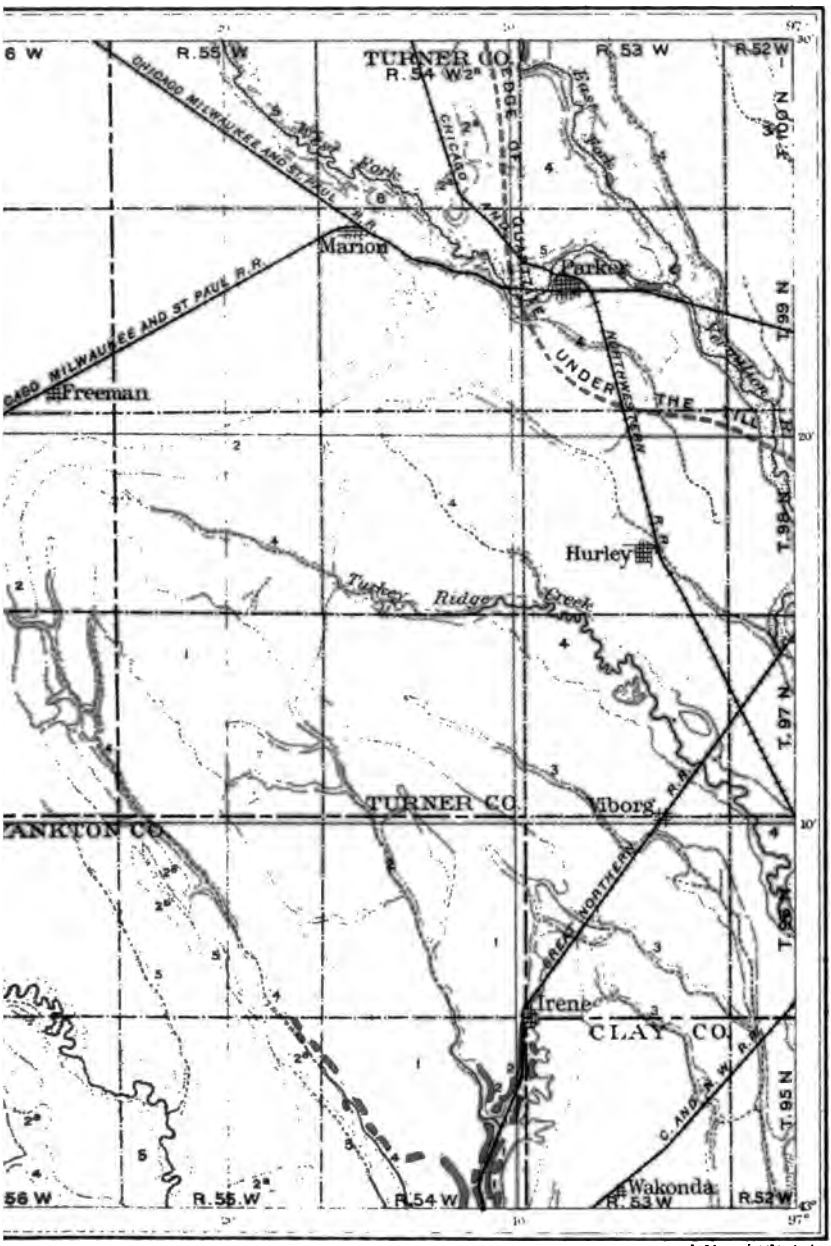
ALGONKIAN

SIOUX QUARTZITE

CRETACEOUS

DAKOTA FORMATION

COLORADO FORMATION



F EASTERN SOUTH DAKOTA

39

MILES

PLEISTOCENE

TILL

ANCIENT CHANNELS
(Numbered in order of occupation)

ALLUVIUM

the surface of the quartzite. Since several hundred feet of strata of marine origin, representing all the ages of Paleozoic time, are found in the Black Hills, the shore of the Paleozoic sea must have extended across South Dakota somewhere west of the present course of the Missouri River. Moreover, as the Triassic formations of the Black Hills testify to an inclosed sea, barren of life, we must believe that during that epoch this inland sea was detached from the ocean.

CRETACEOUS.

Resting upon the Sioux quartzite, as revealed by borings, there are sands, chalk, and clays belonging to the Cretaceous. We have no trace of the earlier beds which represent this age elsewhere, but several hundred feet of the later Cretaceous deposits underlie much of the area.

DAKOTA SANDSTONE.

Resting upon the quartzite, as shown by many borings, there is a series of sandstone and shale which Dr. F. V. Hayden, the first United States geologist who examined this region, named the Dakota formation, from extensive outcrops near the town of Dakota, in Nebraska. This formation is only exposed in this area along James River and Twelvemile Creek above Milltown, and about the junction of Wolf Creek and James River. Its general distribution underground is, however, well shown by the borings of the deeper artesian wells. From these data the formation is known to underlie the area, except in the region about Parker and northeastward. As the surface of the quartzite is uneven and the upper portion of the Dakota sandstone is more or less eroded, the margin is quite ragged and uneven. In the southern part of the area, the Dakota deposits probably have a thickness of 300 or 400 feet, but as deep borings in that region are few, and none are known to have penetrated to bed rock, this is only an estimate. From borings in this area and from exposures elsewhere, it is known that the formation is composed of sheets of sand or sandstone more or less completely separated by thick beds of clay and shale. The sandstone strata are usually of fine-grained, well-washed materials, and vary in thickness from 10 to 100 feet. The clay deposits are in general thick, and very often form a hard shale; locally they include compact limestone, plastic clay, and iron pyrites. The last is very hard and forms a serious obstacle in drilling. The number of sand strata which are water bearing increases toward the south, where the formation thickens.

In eastern South Dakota the upper part of the sandstone is a stratum generally presenting harder layers often spoken of as "cap rock." They are sometimes so hard as to give the impression that the red

quartzite has been struck, but in all cases, so far as known, the cement is calcareous or ferruginous rather than siliceous, as in the quartzite. Its calcareous character is revealed by use of an acid, which causes effervescence; the ferruginous cement is shown by its dark color.

The Dakota sandstone underlies all the area except a small district near Parker. It is exposed extensively along the James River and Twelvemile Creek above Milltown, and also near the mouth of Wolf Creek. At the latter place it seems to be in a low arch or anticline lifted to a height of 25 or 30 feet above the level of the James River. The principal exposures are upon the west side of the river, in sec. 6, T. 98 N., R. 57 W. The material here is a soft, irregularly stratified sandstone scarcely hard enough for building purposes. Exposures on the James River above Milltown begin about a mile above that point in the form of low barren slopes on both sides of the river, which gradually rise until south of Elmspring the upper portion of the formation is about 60 feet above the level of the James River. Here it exhibits a few castellated cliffs. About 1½ miles south of Elmspring, upon the east side of the valley, the following section is exposd:

Section 1½ miles south of Elmspring, South Dakota.

	Feet.
Slope of till	50
Soft brown sandstone, some pebbles above; irregularly stratified, springs below	35
Slope mostly clay, evidently Dakota, to the level of the James River	20

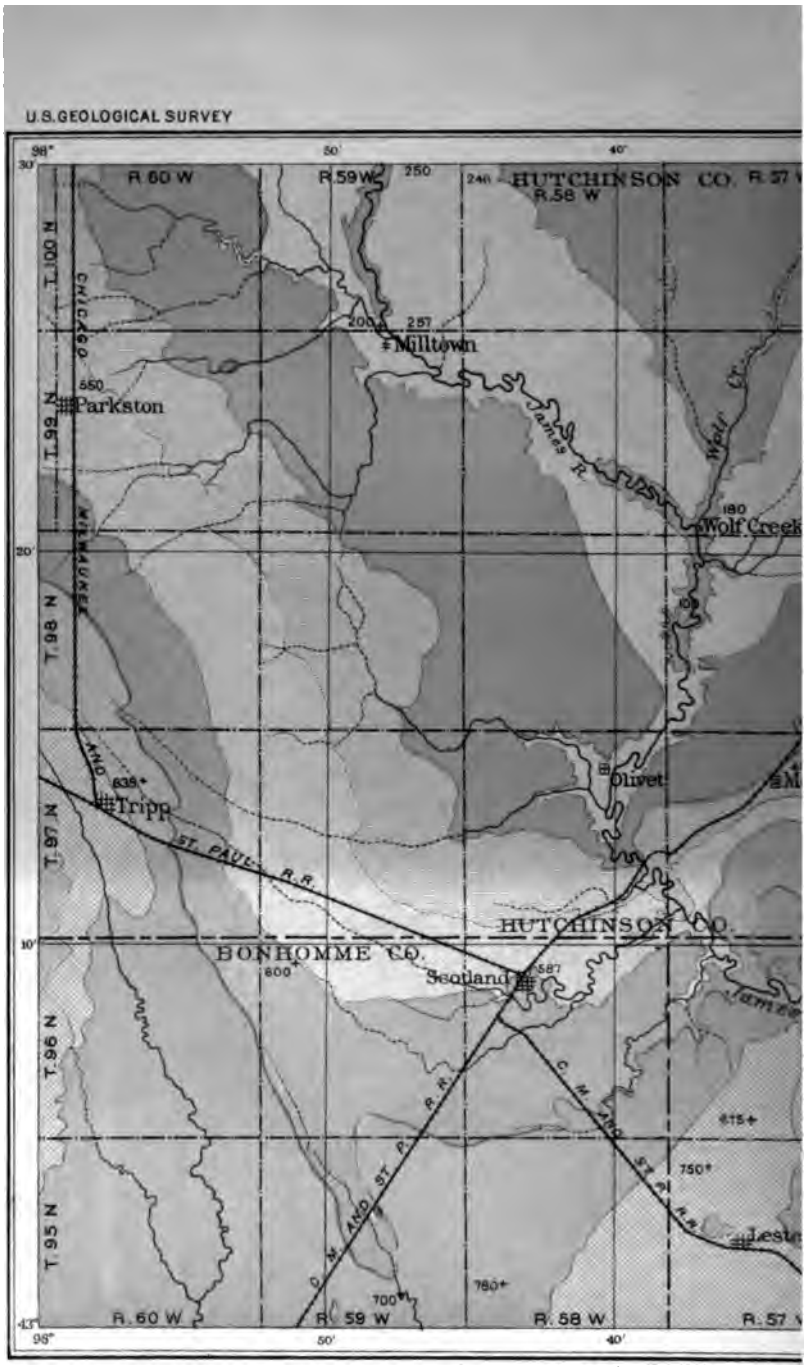
Farther south, about a mile above Milltown, the sandstone is more perfectly consolidated and shows much oblique lamination, and it has been quarried to some extent for building purposes. The sandstone appears on both sides of Twelvemile Creek, following the main stream for 3 or 4 miles. North of the northeast corner of sec. 34, T. 100 N., R. 59 W., it has been quarried considerably. The following section of a well near Elmspring exhibits this formation more completely:

Section in well at Elmspring, South Dakota.

	Feet.
(1) Yellow and blue clay (till) with water at 60 feet	83
(2) Sandstone	8
(3) Sand	20
(4) Sandstone and clay, irregularly stratified	20
(5) "Blue clay" (shale), with one or two strata of sandstone	116
(6) Red quartzite	70

All except No. 1 and No. 6 belong to the Dakota formation.

The formation thickens by the intercalation of other strata, both toward the west and south. Near the James River, at the southern portion of the area, wells indicate that the Dakota formation may be from 300 to 400 feet in thickness. A characteristic view of the upper portion of the formation, as shown on the Firesteel northwest of Mitchell, is given on Pl. IX, *A*.



Note: Figures denote depths of borings
If without + sign quartzite was met with at that depth
All depth areas estimated averages
The quartzite surface has many local irregularities

MAP OF A PORTION
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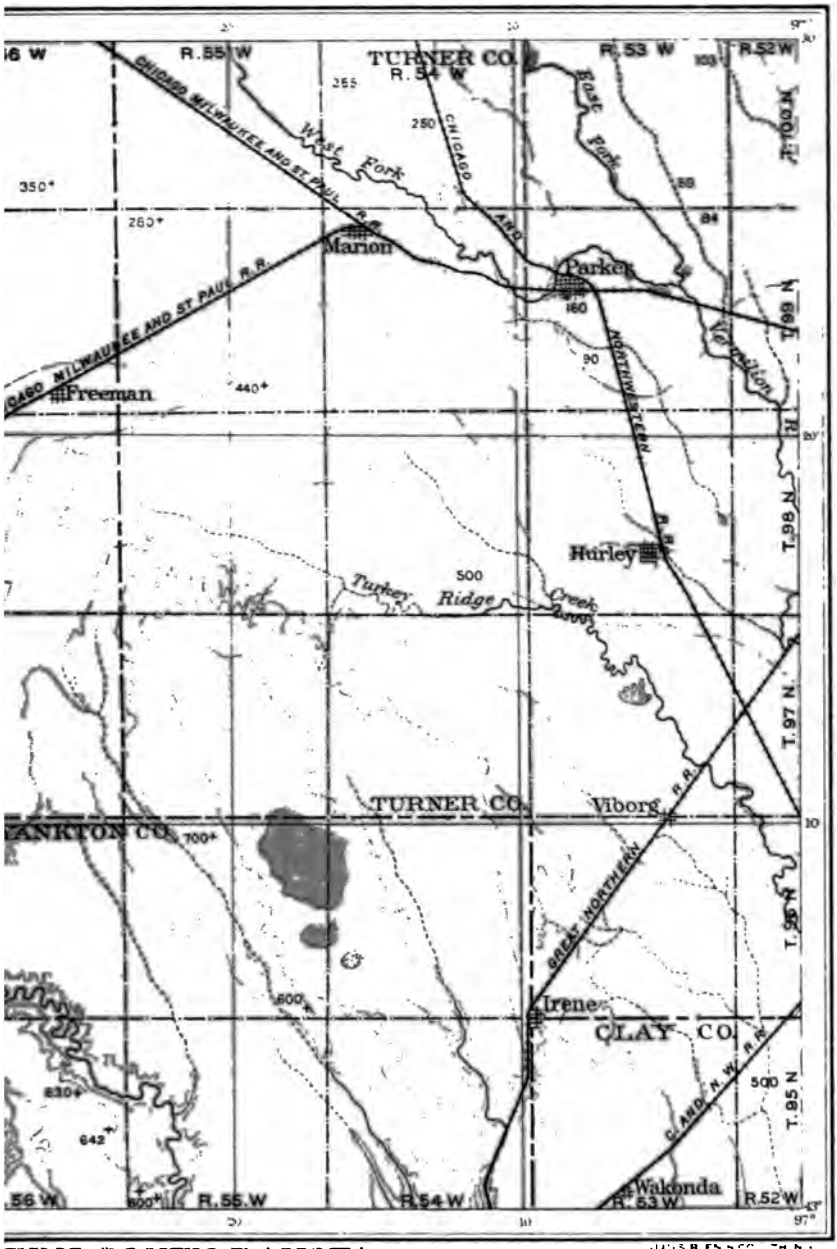
5 0

0′ | 0′ - 100′ | 100′ - 200′ | 200′ - 300′ | 300′ - 400′ | 4



ERN SOUTH DAKOTA

bed rock

99

10 15 MILES

600' 600'-700' 700'-800 800'-900 900'-1000' 1000'-1100'

COLORADO FORMATION.

This includes two series of deposits, which were first separated by Dr. F. V. Hayden. The lower series, composed mostly of shale and clay, was named Benton, from its great development near Fort Benton, Montana, and the upper series, composed largely of chalkstone, was called Niobrara. These two subdivisions, though usually differing considerably in lithologic character, are often grouped together because of the similarity of the fossils which appear in them. Moreover, the line between them is not easily established, because in many places the chalk grades into the clay and shale; and even when fairly pure, enough protoxide of iron is present to give it a bluish tint resembling the shale. It has been found very difficult to separate them in this area by means of the reports of well-borers. One well-borer will say that within a given region he has struck no chalk, but has struck shale and clay. Another will distinguish between the chalk and the clay, recognizing the fact that the former differs from blue shale or "soapstone," while a third may speak of the chalk as a fine sand. Practically, the distinction which is most obvious to the well-borer is that chalk does not become plastic by becoming wet, but acts more like fine sand. On the other hand, the shale, or "soapstone," as it is frequently called, becomes plastic and sticky, and not easily distinguished from the clay except by its hardness.

The Colorado formation is exposed in this region only at a few localities, which are indicated upon the map, viz: Along the South Fork of Twelvemile Creek; on Wolf Creek, about 6 miles above its mouth; 2 or 3 miles south and east of the latter point, and still more prominently in the vicinity of Scotland. It also appears conspicuously along Turkey Creek between Irene and Volin, and also along Clay Creek north of the latter place. From a study of the formations along the Missouri River it is inferred that the Niobrara chalkstone is quite evenly stratified, compact, with some of its layers forming a hard limestone, but more frequently the clayey material is more prominent. From the exposures along the river it would seem that it has a thickness of 150 to 200 feet. Its original thickness was probably not uniform, but it was accumulated in large lenticular masses.

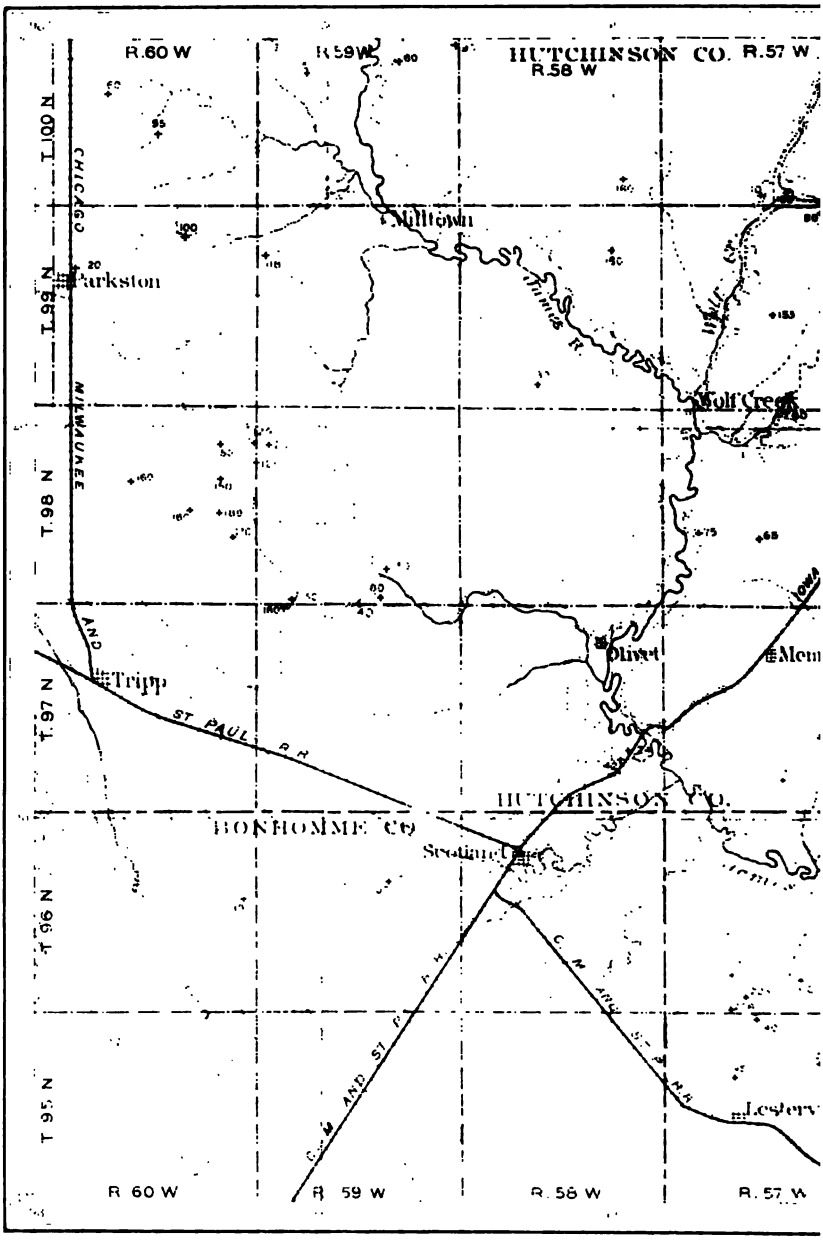
At Scotland and near Milltown the stone has been quarried and used for building. When first taken out it is easily cut with a knife and shaped to any form desired. When thoroughly seasoned it resists the weather so that buildings formed of it have stood for twenty-five or thirty years. When exposed upon a slope it crumbles under the action of frost and becomes a white earthy mass. The protoxide of iron, which colors it blue or light gray when exposed to the weather, becomes a yellow oxide or a carbonate, so that where it is near the surface the chalk *soon becomes a light yellow* or pure white color. It contains

fossils that characterize it elsewhere in the Missouri River Valley, including *Ostrea congesta*, different species of *Inoceramus*, some of them of large size, but usually much broken; a large shell apparently a *Pinna*, and numerous scales and teeth of fishes, both of sharks and common bony fishes. Elsewhere the bones of large reptiles have been found in this formation, but as yet none have been found in it in this area. The chalk rarely shows noticeable shells of Foraminifera, but the mass of the deposit is found by microscopic examination to be composed of coccoliths and other minute organisms found in the chalk elsewhere. At some points the chalk is found to pass laterally into a light-gray clay, and it would seem that chalk and clay might have been formed contemporaneously in neighboring parts of the sea bottom. The difficulty of determining the real thickness of the chalk in this region arises from the fact that well-borers do not readily distinguish between it and the overlying and underlying clays and shales. In no case has it been reported thicker than 100 feet except at Tripp, where it is stated to be nearly 300 feet thick. It is probable that it varies greatly in different localities, though in general it appears to thicken toward the southwest, like the other formations which we have considered. It has not been so much removed by erosion in that direction.

The Benton shale is not clearly exposed at any point in this area. From the study of it along the Missouri River it is found usually to be composed of a dark clay, easily absorbing water and quickly becoming very plastic. At a locality southwest of Mitchell it is excavated for making brick, and one quite striking feature is that the sides of the pit are constantly sliding in, and even in the adjoining prairie the slope is marked with crevasses or cracks, indicating its creeping nature. Similar features have been noted in sec. 33, T. 100 N., R. 59 W., on a slope above the Dakota sandstone and below the level of the chalkstone. It is impossible to estimate the thickness of the formation with any accuracy, but there is clear evidence that the clayey member corresponding to the Benton is found here in considerable quantity. It is probably 50 feet thick. Elsewhere it has been reported in borings as underlying the chalkstone and lying on the sandstones of the Dakota.

Before the deposition of the Colorado formation the Dakota sandstone seems to have been somewhat eroded, especially in the highest portions adjoining the quartzite. Possibly this was due to "contemporaneous erosion" rather than to true unconformity; that is, it was due to the action of tidal currents or waves cutting out channels without any exposure to the action of streams upon a land surface. Moreover, the Colorado overlaps considerably beyond the edge of the Dakota sandstone.

U.S. GEOLOGICAL SURVEY



MAP OF A PORTION (

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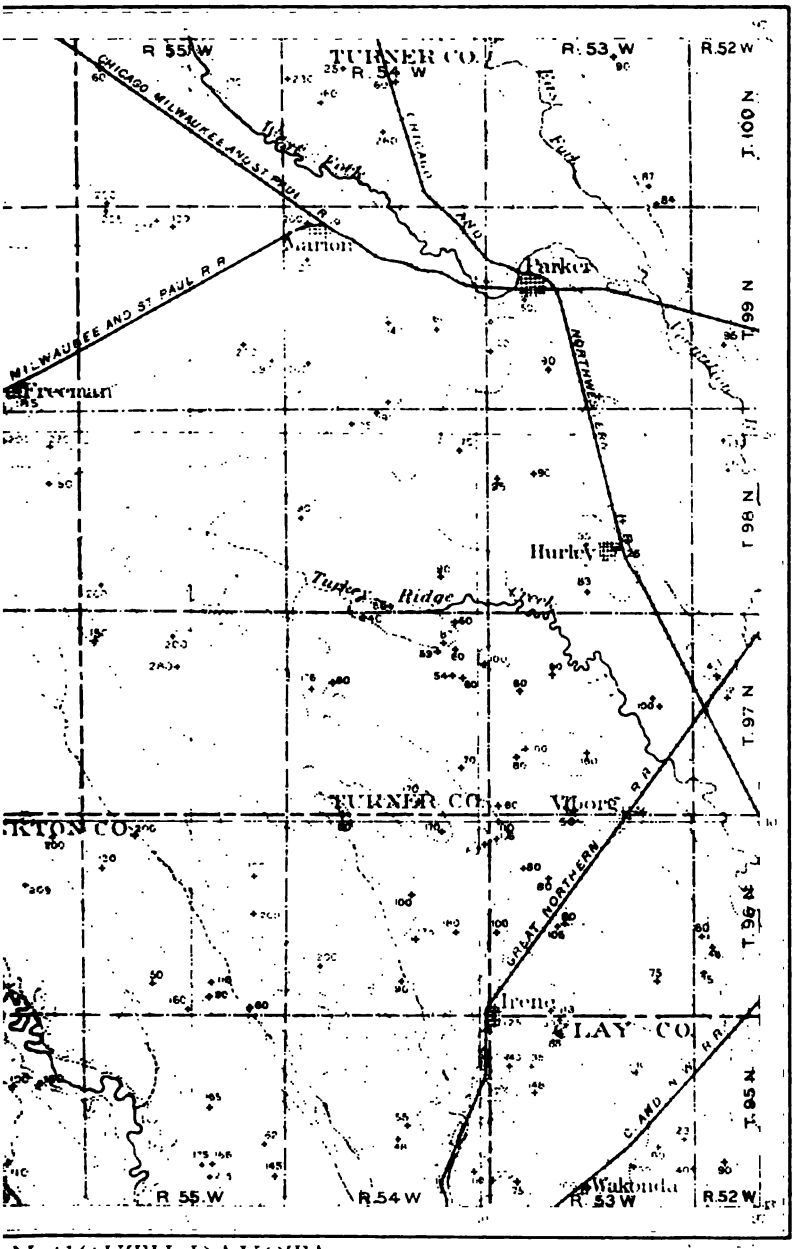


N SOUTH DAKOTA

ase of the till

MILES

200 250 250 300 300 350

PIERRE SHALE.

Pierre shale follows next in succession to the Colorado formation, and is very thickly developed along the Missouri River above the Niobrara chalk. It undoubtedly overlies that formation also in the Choteau Creek Hills, though it has not been distinctly recognized there in exposures or in wells. Upon Turkey Creek, on the east side of sec. 11, T. 95 N., R. 54 W., a few feet of dark, plastic clay overlies the chalkstone, which doubtless is Pierre. Careful examination will probably reveal other similar exposures. It is a formation which often contains remains of marine reptiles and many cephalopod shells. The shales are quite calcareous and their fossils are frequently embedded in large concretions of limestone.

TERTIARY DEPOSITS.

The only natural exposures in the area under consideration which may possibly belong to the Tertiary are beds of a yellow loam resembling loess, which occur overlying the Cretaceous at several points on Turkey Creek, also southeast of the mouth of Wolf Creek. These are underneath the glacial drift and may possibly belong to the Pliocene. Borings in the higher portions of Turkey Ridge and the Choteau Creek Hills reveal thick deposits of sand underneath the till. These also may belong to the Tertiary, and may be even as old as the Loup Fork. On the other hand, it is possible that they are accumulations preceding the deposition of the drift during the Pleistocene. No fossils have been discovered, so no conclusion can be confidently expressed as to their age.

PLEISTOCENE DEPOSITS.

In this region the Pleistocene deposits are very prominent and cover very nearly the entire surface. All the exposures of older rock do not occupy more than 4 or 5 square miles. The deposits of this epoch may be enumerated in chronological order, as follows: (1) The preglacial or circumglacial sands and gravels; (2) the glacial till or bowlder clay, separable into the upper or yellow bowlder clay and the lower or blue bowlder clay; (3) the moraines, which include those of two distinct epochs, with minor subdivisions; (4) terraces and ancient channels, which may be referred to three or four different stages of the glacial occupation of the country; (5) alluvium.

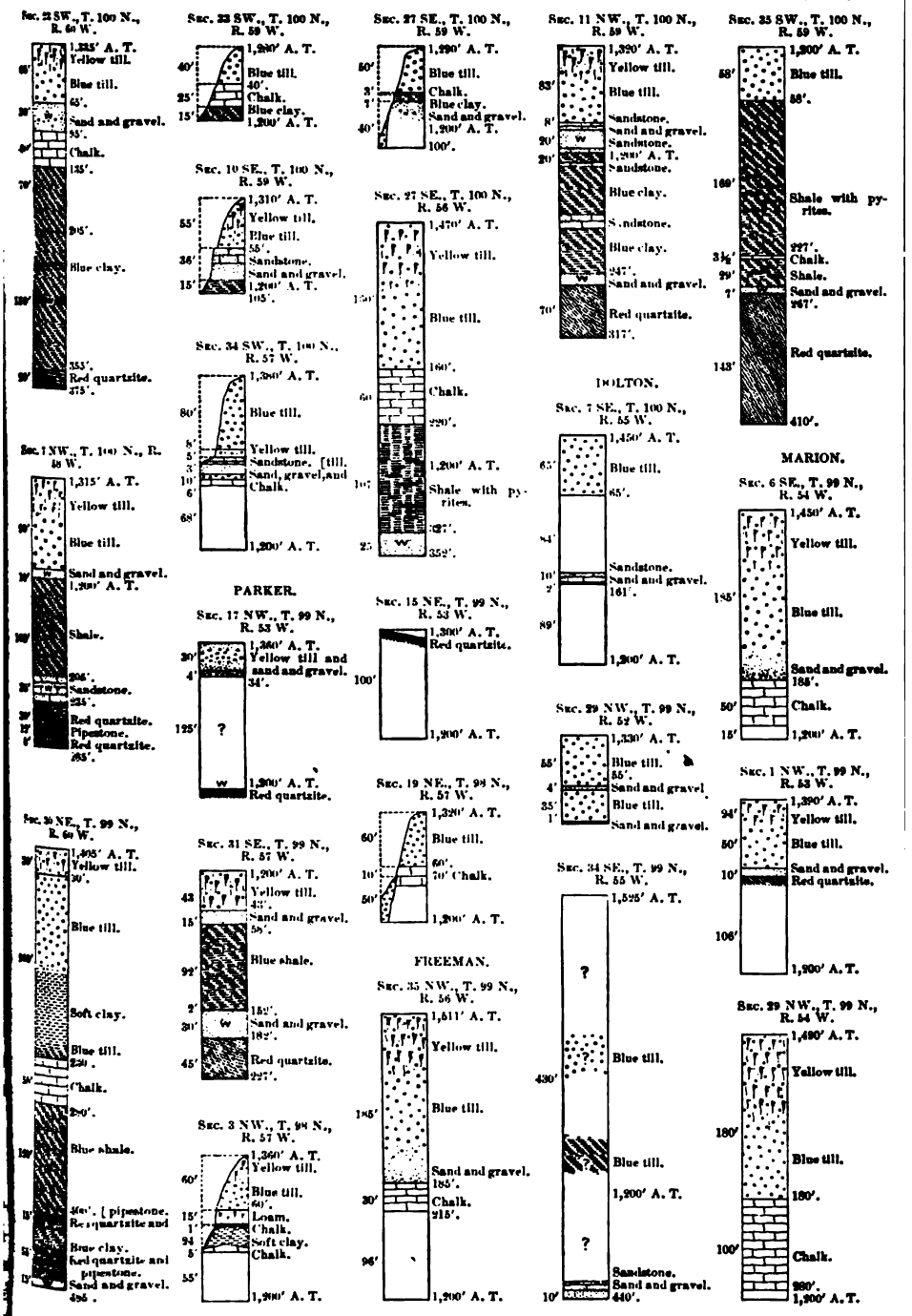
PREGLACIAL OR CIRCUMGLACIAL DEPOSITS.

The preglacial surface was probably covered with silt and clays resembling those of the region now found west of the Missouri. The surface there, however, is probably now eroding faster than at that time, for the base-level of drainage was probably much higher relatively

and of gentler grade. The hillside wash and alluvium was perhaps mor marked than is now found in the trans-Missouri region, but as the ic sheet, which resembled that of Greenland at the present time, slowl advanced from the north there was spread before it almost everywher a fringe or apron of torrential deposits. Heavy sand and gravel bar accumulated along the channels of the principal streams leading fro the ice sheet. A less amount of similar deposit was accumulated i all water courses as their upper portions began to be supplied fro the melting ice. Hence, most of the surface became covered with nearly continuous but uneven layer of sand and gravel, and as th result of the process we find to-day nearly everywhere below the til or blue clay, of this region a stratum of sand and gravel, containin in most cases abundant water. The finer portions of preglacial so and surficial deposits of that time seem to have been washed awa leaving the sand clean and porous. This deposit of sand, which ma be compared to a blanket, lies over the uneven surface of the Cret ceous clays, mantling the upland as well as the lowland. It appea to be generally thicker upon the higher points, where its accumulatio may have been due in part to the action of winds. It is needless, pe haps, to remark that the sands of this deposit, like the bowlder cla above, contain pebbles of granite, greenstone, and limestone. Th deposit is rarely exposed, but there are a few places along the base the bluffs of the James River where it appears. The more notab ones are about a mile below Milltown, and at intervals for 2 or 3 mil above the mouth of Wolf Creek. It may be recognized at oth points by the appearance of springs near the level of the stratum. appears, usually with less thickness, above the older rocks wherev they are exposed. There, however, it is less frequently the source springs, because such points are more elevated, and because the bow der-clay has crept down and covered it more often than where it h been more recently exposed by the action of the streams. Sometim this deposit attains a thickness of 100 feet, but generally it is ve much thinner. In some cases it may be entirely wanting, so that t well-borer passes from the bowlder clay into the Cretaceous bed without noticing the transition. This formation plays an importa part in the water supply of the region and will be further describ under that head.

TILL OR BOWLDER CLAY.

This formation presents the same features that are found in corr sponding regions elsewhere, as in central Minnesota, Iowa, and Ill nois. It is an unstratified mixture of clay, sand, and worn pebbl and bowlders, the last mentioned sometimes attaining a diameter several feet. In this formation are found local developments *stratified sand*, commonly spoken of as pockets, though they ar



LOGS OF WELLS IN *HUTCHINSON* COUNTY, SOUTH DAKOTA.

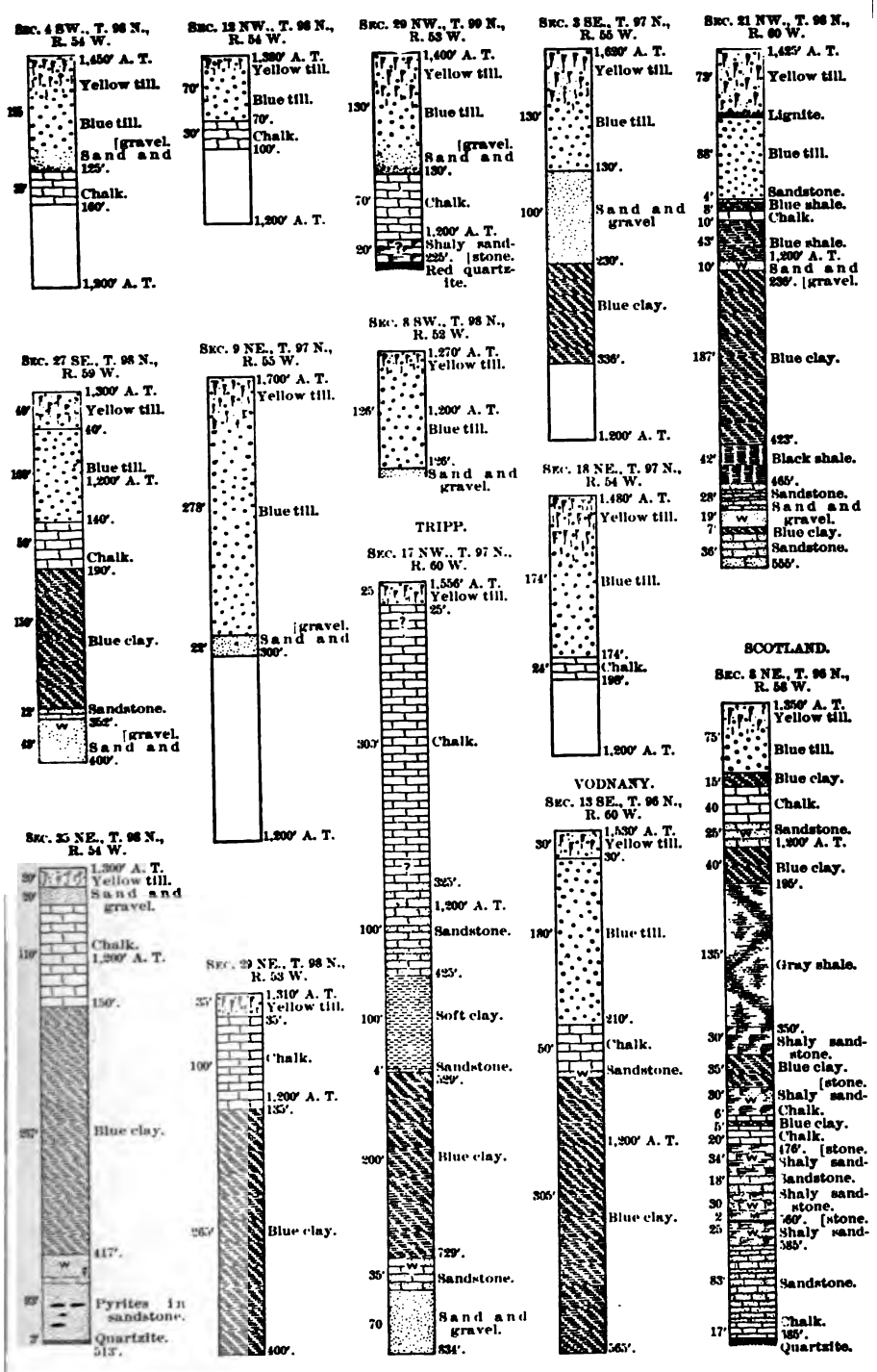
sometimes known to be portions of channels of considerable length, and also of sheets that may locally separate the bowlder clay into two or more members. The till of this region is much more clayey than at points farther east because for some distance the ice had moved over and deeply eroded the dark-colored clays of the Cretaceous. For this reason the erratics are perhaps less frequently striated and planed. The bowlders most widely distributed are gray and reddish granites, and peculiarly compact and fine-grained limestones of a straw color or clear white. The latter contain *Favosites* and cup-corals, with occasional Brachiopods, indicating their Paleozoic origin. Next in prominence are bowlders of a fine-grained trap or greenstone. Besides these, in some portions of the area, a large percentage of the erratics, usually those of smaller size, came from a red quartzite ridge lying to the north. The distribution of these is so remarkable about Turkey Ridge as to attract popular attention. In the main part of this ridge they form about 90 per cent of all bowlders, but outside of or across the valleys of Clay and Turkey Ridge creeks they are very rare. The till varies in thickness from 80 to 250 feet. In general it is thickest upon the higher elevations—as, for example, the Choteau Creek Hills and James Ridge. Near the exposures of the older rocks, which we may suppose to represent points that have resisted preglacial erosion so that they are relatively more elevated, a thickness of less than 50 feet is found, as in the vicinity of Scotland and Elmspring, but over the even surface between Parkston and Olivet it amounts to 125 or 150 feet. Between the Choteau Creek Hills and James Ridge the thickness is frequently 300 feet. It is probable that the thickness is not very uniform and may vary greatly within short intervals. Apparently the surest evidence of reaching the bottom of the till is that the water when struck rises promptly and to a considerable height. This is a fact which well-borers remember and recognize more distinctly than any discrimination of material, for pebbles and bowlders are found in both the till and the sand below. It is not uncommon for two neighbors to sink wells, one having to go to a depth of 250 or 300 feet, while the other may obtain water within 150 or 200 feet. This evidence is not always decisive, for there are sometimes within the till local developments of sand which yield abundant water. However, in many cases the wells have gone farther and demonstrated that in such cases, no till is found below the sand.

It has been noted in other regions that the till consists of two or more numbers belonging to different epochs, and it would seem not improbable that such occurrences may be discovered in this area, but thus far we have been unable to ascertain that this is the case. This is the more remarkable when we consider the number of borings which have extended not only through the till, but to the Dakota sandstone

below. However, since well-borers are not discriminating in this matter, more careful observations may eventually reveal the fact that such a division of the till really exists, at least in the vicinity of moraines. We may mention in this connection a singular phenomenon which occurs about 6 miles east of Wolf Creek colony. In the extreme northeastern corner of T. 98 N., R. 57 W., and in the sections adjoining, are three or four flowing wells obtaining water from a depth of from 55 to 65 feet, while 1½ miles farther west no water is obtained until a depth of about 150 feet is reached, and then it has not sufficient head to flow. This would suggest a division of the till into two members, separated by a sand deposit which does not extend to the second locality mentioned above. This may prove to be a separation of the earlier and older deposit of till, and may extend farther east, and may be caused by the recession and readvance of the ice, corresponding to the interval between the Altamont and Gary moraines. Another explanation may be equally satisfactory, viz, that at one time there existed in the region of flowing wells a subglacial channel which deposited a sheet of sand, which would be strictly subglacial, upon the formation of till already laid down by the glaciers while the till above was of englacial origin and was deposited above the sand deposits of said stream during the final melting of the ice sheet. Similar suppositions may explain similar flowing wells both north and south of the area named and also east of Parkston.

As elsewhere, the upper part of the till has, when weathered, a light buff or yellowish color. This is so prevalent that it is only at unusually recent natural exposures, or in the digging of deep wells, that the blue character of the unweathered till appears. An impression prevails that it differs materially in character from the yellow till, since the yellow till contains water, often in considerable quantity, which supplies the shallow or surface wells of the country. It is a general rule that if sufficient water is not struck before the blue clay is reached, no more can be expected until that formation is completely penetrated. The blue clay is frequently spoken of as joint clay, from the fact that it is usually divided into polygonal masses by irregular joints crossing one another. These allow slight motion whenever the formation lies upon a slope, so that in the vicinity of streams, though less plastic than the Cretaceous clays, it is subject to landslides, which cause it to cover the underlying sands.

The surface of the till, as elsewhere, abounds more or less in shallow basins or lake beds, which may be filled with water in the wet season. In some localities these are so deep that they retain water several feet in depth year after year, but more frequently they are dried up by the advancing summer and are capable of tillage. Since none of them are supplied except by rainfall, even the deepest are apt to become empty after a succession of dry years.



LOGS OF WELLS IN HUTCHINSON COUNTY AND IN NORTHEASTERN PORTION OF BONHOMME COUNTY, SOUTH DAKOTA.

MORAINES.

These are local developments of the till in the form of elevated idges, usually with the surface rougher than elsewhere. In other ords, the surface rises into abrupt ridges or knolls perhaps to the eight of 25 or 30 feet, though we do not find the best examples of uch topography in this area. The intervening depressions and basins re also more numerous than elsewhere. Moreover, the moraines isually present a larger number of bowlders and beds of gravel, and bear other marks of abundant and free-flowing water. They are generally looked upon as marking the line where the edge of the ice sheet remained stationary for a considerable length of time. While the ice gradually brought materials to that point, the process of melting prevented its farther advance, and as the ice melted the clay and gravel contained in it were dropped along its edge. With this explanation we can easily understand how some areas would be much more abundantly supplied with materials than others, because of differences in velocity and load of the ice and in its relation to the attending waters. We rarely find the edge of the ice sheet clearly marked for any great distance by morainal deposits. The moraines are usually best developed at higher levels. Where the edge of the ice sheet rested in still water, whether in a lake or a sluggish stream, the material brought up by the ice would be widely distributed by the water and a comparatively level surface would be formed. Where the edge of the ice was washed by the stream for some distance, the material contributed by the ice would be carried away and hence not deposited as an accumulation.

In the area under consideration we have portions of two systems of moraines, with minor subdivisions. These are believed to belong to the Wisconsin stage of the Glacial epoch, and are known as the first, or Altamont moraine, and the second, or Gary moraine. The first moraine includes the hills in the northeastern corner of the Parker quadrangle, and the main portions of Turkey Ridge and James Ridge, and the whole of the Choteau Creek Hills. The surface in all these areas is more elevated than the region within the moraine, and is usually marked with stony hills, with more numerous and deeper basins between.

The second, or Gary moraine, is represented by the ridge beginning east of the West Fork of the Vermilion and forming the divide between it and the East Fork of the Vermilion. It passes south and southeast around the head of Turkey Ridge, then south along the east side of the same to the southern line of the area, where it turns west and skirts the eastern slope and around the northern end of James Ridge; hence, for several miles, it is imperfectly represented by the ridges near Lesterville and the gravelly hills at Scotland. These seem to mark the earlier stage of its deposition. North of Olivet it again appears

more continuous, but of subdued form, and extends northwest alo the divide south of Twelvemile Creek to the northwest corner of t area. In general, this moraine is of lower elevation than the first, a has its knolls less prominent. Its highest portion is southeast Freeman, where it attains an altitude of more than 1,600 feet.

ANCIENT DRAINAGE SYSTEMS.

Connected with these moraines are ancient systems of drainag quite distinct at several points from those of the present time. We wi not dwell upon them further than to call attention to some of the mo notable cases. During the occupation of the first moraine the drai age from between the lobes of ice occupying the Vermilion Vall and the James was by means of Turkey Creek and its branches. Sim larly, upon James Ridge, between the James River lobe of ice a the one to the west, are imperfect traces of a similar system. Duri the occupation of the second moraine the drainage was largely dow the present course of the West Fork of the Vermilion River, Turk Ridge Creek, Clay Creek, and Beaver Creek, and at that time a lake considerable extent occupied the Vermilion Valley, east of Hurley. much more transient one also occupied the region west of the ice she northwest of Scotland, which, for a time, drained toward the south in the upper part of Beaver Creek, but soon found its outlet down t James River Valley. The latter stage of this lake seems to have pe sisted along the valley of Dry Creek, east of Parkston, until t formation of the later part of the Gary moraine.

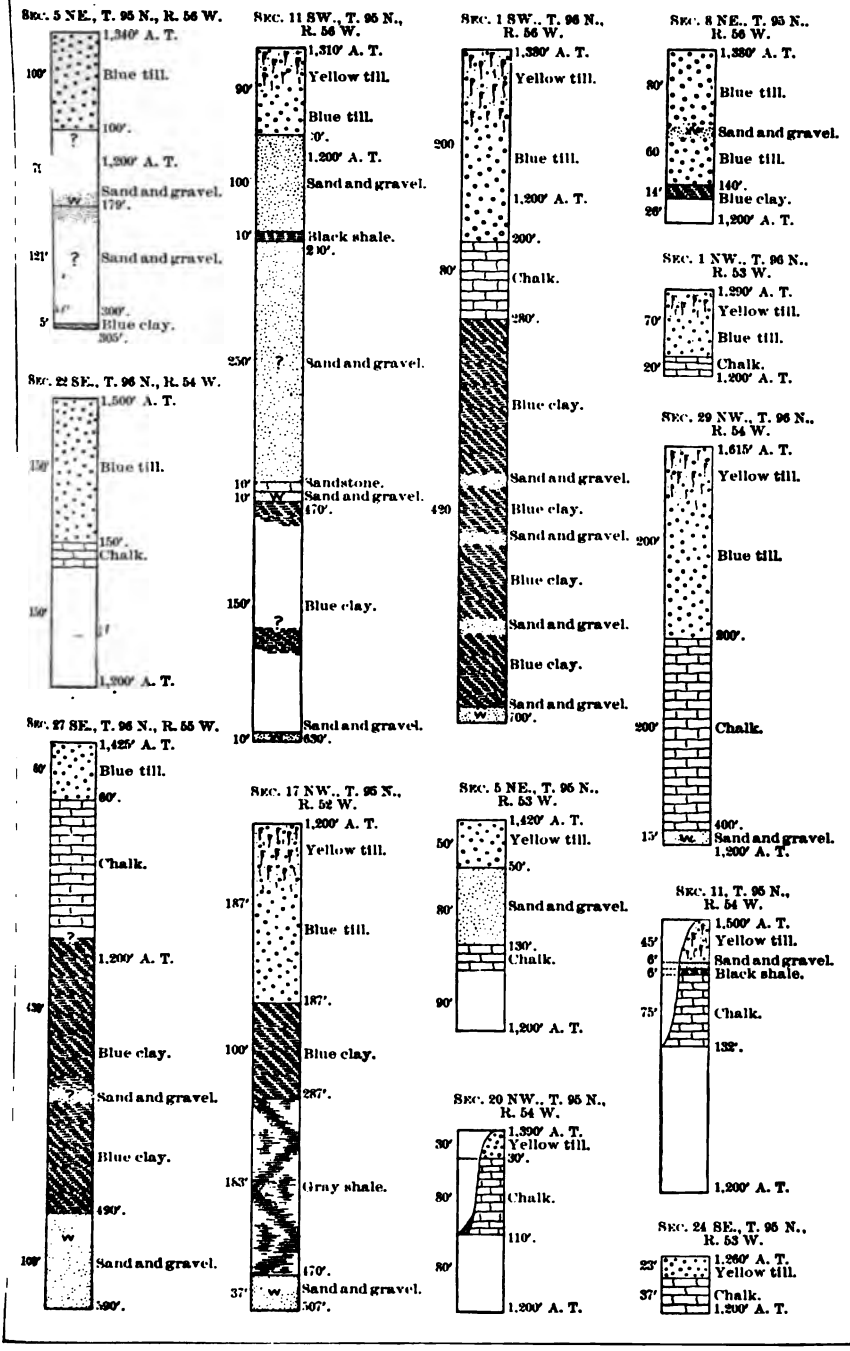
WATER SUPPLY.

Under this head are included the most important economic results the study of the geology of this area. The subject of water supp is divided into surface waters and underground waters. Under t former are included lakes, springs, and streams, and under the latt are included the supplies which furnish shallow wells, artesian well and tubular or pump wells.

SURFACE WATERS.

LAKES.

These receive their waters directly from the rainfall and endu according to the extent of their drainage basin, the depth of the reservoir, and the dryness of successive years. The rainfall of t region varies greatly during different seasons. Its average is abo 25 inches. After a succession of wet years, the lake beds over t whole region are filled with water, and in the spring also, if the has been much snow, the same is true. However, in the latter pa



LOGS OF WELLS IN YANKTON AND CLAY COUNTIES, SOUTH DAKOTA.

of summer nearly all of them become dry. Some of the more important are marked upon the map as regular lakes. Within the last twenty-five years some lakes have passed through a summer with 10 or 15 feet of water, and a few years later have become dry enough for tillage.

SPRINGS.

Permanent springs are rarely found, but a few occur along the James River and its principal tributaries. They receive their waters from the various formations which are treated more fully under the head of underground waters.

One class of springs which, perhaps, are not often recognized as such derive their waters from the rainfall seeping through the upper part of the drift into the water courses. Since the water from them is contained in isolated basins or waterholes in the water courses, many may not recognize the fact that the water supplied comes from below the surface, but this is doubtless the fact. To the constant movement of the water, more fully described under the head of underground waters, is to be traced the purity of the water in the ponds and their freedom from stagnant properties.

Other springs are derived from the gravel and clay deposits capping the ancient terraces or lining the old water courses of the Glacial epoch. As an example of this may be mentioned a spring in the southwest corner of sec. 34, T. 100 N., R. 59 W., which is supplied from the gravel deposits in an old channel of the James River about 100 feet above the present stream. Another less copious spring appears on sec. 3 of the same township, where the same channel meets the deeper valley of Dry Creek. Another spring from these same deposits appears on or near sec. 15 of the township to the south. It is probable that careful examination would reveal several more of similar origin.

Still other springs derive their waters from the sands below the bowlder clay. These fail to bring water to the surface except where it rests upon underlying clays, probably Cretaceous, although this can not always be easily demonstrated. Springs of this sort have been noted at the base of the bluffs on the right bank of the James River at a number of points between the mouth of Dry Creek and Wolf Creek. It is probable that a further search would discover many more.

A few springs are known to come from joints or porous strata in the chalkstone. Such are found near Scotland and along Turkey Creek. Their waters are frequently unpalatable from impregnation with alum salts.

Other springs seem to be supplied from the sandstone of the Dakota formation. Cases of this kind have been noted a mile or two south

of Elmspring, where the water escapes from the base of the sandstone as it rests upon the shaly clay below. Other springs which we believe are supplied from the same geological stratum are found near Olivet. They are two in number, the smaller appearing 10 or 12 rods southeast of the bridge crossing the James River east of Olivet; the other about a quarter of a mile farther north, within a few rods of the edge of the bottom adjoining the river. Both of these springs or ponds, as they may be called, are surrounded with bulrushes and are of circular form. The water rises nearly to the level of the bottom land, which is 10 feet higher than the ordinary stage of the James River nearby. Since they are more than a half mile from the base of the bluffs on the east, and the water is higher than can be found at ordinary stages in the James River within 2 or 3 miles farther upstream, it seems clear that the supply is derived from a stratum of the Dakota sandstone, and that we have here, as it were, natural artesian wells. The large spring has a diameter of about 150 feet of open area besides that occupied by bulrushes. Quite similar to the Olivet springs is the one 5 miles north of Mitchell, shown on Pl. IX, *B*. It differs only in having higher banks. Pl. X, *A* shows another type, escaping close to Sioux quarzite ledges on Enemy Creek, southeast of Mitchell. It is probable that similar leaks from the artesian stratum escape into the trough of the James River below the water, or at least below the surface. Some of the small marshes which are found upon the flood plain may be supplied from this source, although probably most are supplied from the waters escaping from the sand sheet below the till.

STREAMS.

The James River is the only stream in this area which may be depended upon to contain running water at all times. The lower portions of Wolf Creek, Twelvemile Creek, and Lonetree Creek are rarely entirely dry, but above the last mile or two of their course the water in the latter part of summer rarely flows upon the surface.

UNDERGROUND WATERS.

The most accessible underground waters are those flowing near the surface of the ground or seeping through the upper portion of the till toward a water course, where there are shallow accumulations of sand, which form conduits for it. It flows slowly through the lower portions of these sand accumulations and appears at intervals in waterholes along the upper portions of the more prominent streams. In these it rarely comes forth in sufficient strength to attract attention. Where the slope of the surface is toward an undrained basin, the water, flowing on yellow till, contributes to the level of the water in an open lake until the water level sinks below the surface, as it soon does in the great majority

DAKOTA SANDSTONE ON FIRESTEEL CREEK, IN TOWNSHIP 104 NORTH, RANGE 61 WEST.

B. ARTESIAN SPRING, IN TOWNSHIP 104 NORTH, RANGE 60 WEST.

of cases. It may then be drawn upon by shallow wells which for a number of years may be entirely adequate for the demands of neighboring farms, but in time of drought gradually become exhausted. Where the surfaces slope toward a water course, the water accumulates in larger supply, but it also flows away sooner. Shallow wells, therefore, along the ancient water courses which were occupied by streams of considerable size during the presence of glaciers in the vicinity, afford some of the most copious wells in the region, some of them being quite shallow. These shallow wells were the main dependence of the farmers of the region in the early settlement of it. In 1881 and a few years subsequent, water was abundant in these surface wells, but after a series of dry years this supply became exhausted and farmers were forced to go deeper for their water supply.

The next supply was that derived from the sand and gravel at the base of the drift. These are reached by penetrating the till, which is done by boring, often to 300 feet below the surface. This depth would be a serious disadvantage were it not in a measure compensated for by the rise of the water, so that in many such wells the water stands within 5 to 25 feet of the surface; some, in fact, became flowing wells. There are wells of this class in the area which have been flowing for over twenty years. The depth to these subtill waters is shown on Pl. V. As we have elsewhere stated, the thickness of the till varies considerably within short distances. Hence, the depth indicated on the map sometimes may not be within 25 to 50 feet of the point where water will be reached, although in the majority of cases it is believed that it will be much nearer. Moreover, as will be readily understood, the subtill sand sheet is not everywhere filled with water, especially in higher regions. Therefore the sand may be reached and passed through to the Cretaceous shale below without yielding water. This seems to have been true in some cases in the Choteau Creek Hills. On the other hand, flowing wells are frequently found at lower levels. Such areas, however, are of comparatively slight extent, and the pressure head is not level, but slopes irregularly with the surface. This is doubtless due to the slow motion of the water below. The areas where flowing wells from this source have been obtained are indicated on Pl. II. Probably others may be found by boring, especially at intermediate altitudes remote from important streams. In some cases the erosion of the ravine or watercourse is that which renders the flowing wells possible, because it decreases the altitude of the surface while the head remains constant. As we have already stated under General geology, cases are not infrequent where deposits of sand and gravel are locally developed in the till itself. These frequently furnish a copious supply of water, and in such cases wells yield water without entirely penetrating the till. On the other hand, sands below the till are absent at some points. In

such cases no water is likely to be reached short of the main artesian supply. The deep wells supplied from this source are commonly known as tubular wells, though that term strictly indicates the construction of the pumps used. Hence, we may conveniently speak of the Pleistocene subtill sands as the "tubular-well supply."

It seems evident that the original source of this supply is the rainfall, the same as in the case of shallow wells, but it is a more constant supply, because the water enters it more gradually. It is more continuous, and does not waste in evaporation as in shallow wells. It should not, however, be considered inexhaustible, because if a tubular well is drawn upon too freely it may be expected to gradually fail, especially if it is in an elevated region.

The way in which the water enters this stratum is not well understood. In general, the till seems to be so perfectly impervious that, especially at lower levels, it prevents the escape of the water below quite completely. We have before called attention to the joints in the clay, which, at certain times, especially in more abrupt portions of the surface, and after drought, are probably opened sufficiently to allow water to enter from the surface. Besides, it is not improbable that the bottom of the ancient channels may at some points cut through the till to the lower Pleistocene sands in such a way as to add materially to this supply.

WATER FROM THE OLDER STRATA.

In case sands belonging to the Tertiary should be discovered in the region it is likely that they will be closely connected with the lower Pleistocene sands, and hence we need not discuss them separately. The chalkstone of the Colorado formation is porous and water bearing; in fact, springs are occasionally found flowing from it. We have already spoken of springs from it at Scotland. It exists in such detached masses, and wherever it affects wells is so closely underneath the drift that it need not be treated at any length separate from the tubular-well supply.

It has been found convenient in some places to use chalk as a filter to keep out the sand from the bottom of the well. Moreover, there appears in some places, although not certainly in this area, a stratum of sandstone in the chalk which affords water more copiously and may sometimes have a relation similar to that of the Dakota sandstone underneath.

MAIN ARTESIAN SUPPLY.

Those who have studied the matter universally agree that the main artesian supply is from the sandstone and sand beds of the Dakota formation. This remarkable formation is the source of water in Texas and Colorado, as well as in this region. It owes its efficiency to four

A. SHERRILL SPRING, ON LOWER ENEMY CREEK.

B. KILBURN RUN, FED BY KILBURN WELL, NORTH OF MOUNT VERNON, SOUTH DAKOTA.

conditions: (1) Its great extent, underlying most of the Great Plains from the Rocky Mountains to about the ninety-fifth meridian. (2) Its highly elevated western border, located in the moist region of the mountains and crossed by numerous mountain streams. (3) The fact that it is extensively sealed on its eastern margin by the overlapping clays of the Colorado formation, and where that is not the case, by the till sheet of the Glacial epoch. (4) The excavation of wide areas, especially in Dakota, by older streams, so as to bring the land surface below the pressure height or "head" generated by the elevated western border of the formation. From this source also are derived the copious pumping supplies of water over wide areas, where the pressure is not sufficient to produce flowing wells.

Pl. X, *B* gives a vivid impression of the possibilities of such wells. The flow is through a 3-inch pipe and from a depth of only 337 feet. The stream rivals the Firesteel nearby in the amount of flowing water. It is estimated to furnish over 1,000 gallons a minute. Most of the wells in the area are much smaller and are much more convenient for ordinary farm use, besides being more enduring.

The Dakota deposits underlie nearly the entire area treated in this report, but from the relation of pressure to surface the true artesian area is limited approximately as represented upon the map (Pl. II).

In boring wells the term "flow" is used by some persons to indicate that the water has sufficient pressure to rise some distance in the well, but it is more customary to limit the term to those cases in which there is sufficient force for the water to rise to or over the top of the well. From a comparison of the sections of different wells it appears that the sheets of sand are more or less separated by intercalated sheets of clay, the permeable sandy deposits extending out into thin, wing-like sheets. In this way there are in this area at least three horizons with well-marked flows. The first or uppermost of these probably corresponds to the stratum which is exposed above Milltown. This bed, of course, can not hold water under pressure sufficient to produce flowing wells in the vicinity of its exposure where the head is lost by leakage. The second flow is that which supplies most of the wells northeast of the town of Tripp. The third is that probably reached in the deep well at Tripp. Probably others occur still deeper in the southeast portion of the Olivet quadrangle.

From a study of the sections of the wells it is evident that the successive flows rise somewhat toward the exposures of quartzite, but that the higher water-bearing strata considerably overlap those below. In other words, the lowest sandstone stratum of the Dakota does not extend as far northeast by several miles as those higher up. There has been no effort to express on the map the extent of the different water-bearing strata, but they may be inferred from the irregularities in the depths given.

PRESSURE.

From a superficial study of artesian wells it might be thought that the water, especially in particular artesian basins, has the same head or would everywhere rise to the same plane. Such, however, is far from the fact in the wells of South Dakota. In general, the pressure declines toward the margin of the water-bearing strata. This is readily explained, as noted above, in the shallow basins by supposing that the water is moving as a slow current toward leaks along the margin of the formation where it joins the older rocks or where fissures may connect it with the bottom of streams. Each flow, in general, shows this same decline in pressure toward the northeast.

Moreover, from what we have said about the relation of the Dakota sandstone to the Sioux quartzite and Colorado clays, one can easily understand how the lower flows are found to have higher pressure. Their leakage is much less free. Upon the map (Pl. II) there are contours representing the altitude of "head," which in its downward slope east may be regarded as a "hydraulic gradient." From the nature of the case, it would be impossible to represent the pressure for each water-bearing stratum, and we have therefore taken the data from the more important wells; or, in other words, the lines of altitude of "head" may be taken as representing the relative pressure in the more available and accessible stratum. It is not unlikely that the sinking of wells 300 to 500 feet in depth, to the third or fourth flow, may show considerably increased pressures. It will be observed that the lines have a distinct curve toward the south and east. This may be ascribed, especially in the case of the 1,400-foot line, to the fact of locally increased leakage along the James River Valley, together with the general diminution of supply to the south and east in eastern South Dakota.

The pressure in the wells of this area has not been very generally noted. Many of the wells are small and intended simply for farm supply, so that the pressure has not been an important consideration. At Tripp the pressure was 10 pounds and at Scotland perhaps 4 or 5 pounds, soon after the wells were finished, but at present they barely flow. The wells southeast of Parkston are reported to have a pressure of 40 pounds, and at that place 55 pounds has been recorded recently.

VARIATION OF PRESSURE.

This brings us to a consideration of certain influences that affect pressure. Under this head we shall consider, briefly, a variety of influences that have been found to affect pressure, and will give others the cause of which has not been discovered.

(1) Variation in adjacent wells. Places are not infrequent, although *not notable in this* area, where wells at nearly the same point have

widely different pressure. In some cases it is evident that the wells are supplied from different sources or flows. This conceivably may be true, even when the water is from the same depth; for, as before stated, the water-bearing strata branch, and do not always extend upon the same level. More frequently, however, these wide local variations are due to the pressure from the stronger flow expending itself along the outside of the pipe into an upper stratum of less pressure.

(2) Variation in the same well at different depths. This need not be dwelt upon, for we have already explained how lower strata are more perfectly sealed on their eastward margin and therefore display higher pressure.

(3) Variations in the same well because of wells in the vicinity. The distance to which the influence of the escape of water from a well extends may reasonably be supposed to be directly proportional to the amount of water discharged. We may conceive that the flow of the well produces a depression in the surface, or "head," so to speak, proportional to the amount of water discharged, somewhat as in the case of an opening in the bottom of a reservoir. If the flow is rapid the depression may be great, so that if the well is closed its pressure will be at first, perhaps, several pounds below the original pressure, but as the water flows in from adjacent areas the pressure in the well will gradually regain its former amount. So, if two wells are near each other, we can not expect that the closed pressure of one will approach very closely to the original figure if the other is left open.

(4) Effect from varying barometer. As the pressure taken is with a gage affected by the pressure of the air, it follows that when the barometer is high the pressure of the fluid within will be correspondingly diminished. The influence is, of course, slight, and will be overlooked unless the pressure in the well is very weak. Under such circumstances, however, an increase of the pressure of the air may sometimes be sufficient to stop the flow and, conversely, a low barometer may increase the flow.

(5) Periodic variations. In a number of the weaker wells there has not only been a decline of pressure, but from time to time an increase. This increase has been in some cases related to the time of year, the spring being sometimes marked by a stronger flow. This again varies according to years, and it is believed to be most satisfactorily explained by supposing that the water is obtained from the melting of snows or from streams subject to floods.

(6) Effect of varying leakage in the vicinity. This has been observed in wells near the Missouri River. When the river is high the pressure in the wells increases. It is easily explained by supposing that there are points of leakage underneath the surface of the river, and that the increase of hydrostatic pressure from the stream checks the leakage to such an extent that it increases the pressure in adjacent wells. While

this has not been noted in the area, it is not improbable that examples occur near the James River. This variation, of course, is slight, and would be unnoticed except in very weak wells.

Upon the map (Pl. II) approximate depth to the surface of the Dakota sandstone is represented. As was stated in the discussion of that formation, this does not always directly mark the upper limits, but more definitely the level from which flowing wells may be obtained. In cases where water is not found at the depth indicated the boring may be hopefully carried through lower horizons to bed rock, the depth of which is shown on Pl. IV. In the southeastern corner of the area and along its western side the Dakota sandstone is thicker and probably carries more water-bearing strata.

HINTS ON THE CONSTRUCTION OF WELLS.

Although the practical application of the following hints belongs to the work of the well-borer, and may be discussed more efficiently from the standpoint of an engineer, yet they may be advantageously noted here in connection with the geological facts.

(1) Since the pressure in the upper flows is less than in the lower by many pounds to the inch, it is very important that the communication between the lower flows and the higher should be entirely cut off. Otherwise the full pressure from the lower stratum will not be observed at the mouth of the well, but will expend itself by leaking into the strata below the surface. The desire of the well-digger to keep his pipe loose may tempt him to leave the bore too large—hence the danger we speak of.

(2) It is very desirable that the larger pipe lining the bore be firmly fixed in the hard stratum above the water-bearing rock. This may be done in most localities, as a compact stone is found just above the porous sands which bring the water. Much depends upon this, for if a pipe be left loose, and the opening in the rock left incompletely stopped, water is likely to escape around the pipe and, if not checked, may eventually destroy the well.

(3) A well should be sunk as rapidly as consistent with good work, especially after water has been reached. Otherwise, the great pressure of the water may cause it to erode an irregular opening and prevent the accomplishment of the two points already given.

PERMANENCE OF ARTESIAN SUPPLY.

All natural products are liable to exhaustion. With gold, coal, and other metallic products no general rules can be laid down by which we may foretell how soon the supply may fail. With water it is otherwise. As we have already said, multiplication of wells must *tend to exhaustion*. If, however, the loss by wells and leakage does

ɪt exceed the annual supply which enters the formation on the west, equilibrium may be gained which will be as constant as in a river. may be expected to have similar fluctuations. At present the pres-re in wells in the area discussed is generally slightly declining. ɪme wells of original low pressure have ceased to flow, as at Scot-ɔd, Tripp, in sec. 12, T. 95 N., R. 56 W., and in other places, but e great majority have failed but little. There is no apprehension early failure.

From the sheet-like form of the water strata and their nearly hori-ntal position, the decline of pressure will necessarily be very regu-: and gradual. If, to illustrate, a well having a pressure of 50 unds should show a decline of 2 pounds a year, under similar condi-ɪns it would last twenty-five years with gradually decreasing flow. oreover, it is possible, if not probable, from the wide extent of the ɪkota sandstone at high altitudes toward the west, that there is a serve supply which may become more available as the head declines. Many of the reported cases of failure from other portions of the tesian area have been shown to be due to stoppage by sand or to sub-rranean leakage resulting from the rusting of the pipe or imperfect nstruction, and sometimes from the breaking of the pipe by caving. Until more is known of the circumstances controlling the supply ttle more can be said upon this point.

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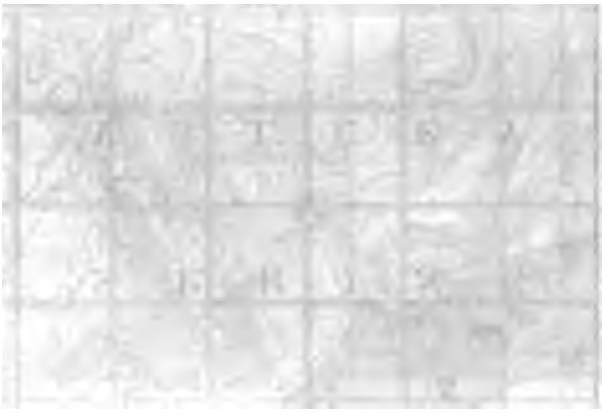

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1895.

Sixteenth Annual Report of the United States Geological Survey, 1894-95, Part II, Papers of an economic character, 1895; octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894; octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Bighorn Range and Bighorn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar years 1893 and 1894, by F. H. Newell, 1895; octavo, 175 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895-96, Part II, Economic geology and hydrography, 1896; octavo, 894 pp.

Contains papers on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett; and "Preliminary report on the artesian waters of a portion of the Dakotas," by N. H. Darton.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 336 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896-97, Part IV, Hydrography, 1897; octavo, 736 pp.

Contains a "Report of progress of stream measurements for the calendar year 1896," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "New developments in well boring and irrigation in South Dakota," by N. H. Darton; and "Reservoirs for irrigation," by J. D. Schuyler.

1898.

Nineteenth Annual Report of the United States Geological Survey, 1897-98, Part IV, Hydrography, 1898; octavo, 814 pp.

Contains a "Report of progress of stream measurements for the calendar year 1897," by F. H. Newell and others; "The rock waters of Ohio," by Edward Orton; and "A preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian," by N. H. Darton.

1900.

Twentieth Annual Report of the United States Geological Survey, 1898-99, Part IV, Hydrography, 1900; octavo, 660 pp.

Contains a "Report of progress of stream measurements for the calendar year 1898," by F. H. Newell, and "Hydrography of Nicaragua," by A. P. Davis.

Water-Supply and Irrigation Papers, 1896-1900.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost, as noted above. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Postage stamps, checks, and drafts can not be accepted. Correspondence relating to the publications of the Survey should be addressed to **The Director, United States Geological Survey, Washington, D. C.**

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WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phoenix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897.
7. Seepage waters of northern Utah, by Samuel Fortier, 1897.
8. Windmills for irrigation, by E. C. Murphy, 1897.
9. Irrigation near Greeley, Colorado, by David Boyd, 1897.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker, 1898.
11. River heights for 1896, by Arthur P. Davis, 1897.
12. Underground waters of southeastern Nebraska, by N. H. Darton, 1898.
13. Irrigation systems in Texas, by William Ferguson Hutson, 1898.
14. New tests of pumps and water lifts used in irrigation, by O. P. Hood, 1898.
15. Operations at river stations, 1897, Part I, 1898.
16. Operations at river stations, 1897, Part II, 1898.
17. Irrigation near Bakersfield, California, by C. E. Grunsky, 1898.
18. Irrigation near Fresno, California, by C. E. Grunsky, 1898.
19. Irrigation near Merced, California, by C. E. Grunsky, 1899.
20. Experiments with windmills, by Thomas O. Perry, 1899.
21. Wells of northern Indiana, by Frank Leverett, 1899.
22. Sewage irrigation, Part II, by George W. Rafter, 1899.
23. Water-right problems in the Bighorn Mountains, by Elwood Mead, 1899.
24. Water resources of the State of New York, Part I, by George W. Rafter, 1899.
25. Water resources of the State of New York, Part II, by George W. Rafter, 1899.
26. Wells of southern Indiana (continuation of No. 21), by Frank Leverett, 1899.
27. Operations at river stations, 1898, Part I, 1899.
28. Operations at river stations, 1898, Part II, 1899.
29. Wells and windmills in Nebraska, by Erwin Hinckley Barbour, 1899.
30. Water resources of the Lower Peninsula of Michigan, by Alfred C. Lane, 1899.
31. Lower Michigan mineral waters, by Alfred C. Lane, 1899.
32. Water resources of Puerto Rico, by H. M. Wilson, 1900.
33. Storage of water on Gila River, Arizona, by J. B. Lippincott, 1900.
34. Geology and water resources of southeastern S. Dak., by J. E. Todd, 1900.

In addition to the above, there are in various stages of preparation other papers relating to the measurement of streams, the storage of water, the amount available from underground sources, the efficiency of windmills, the cost of pumping, and other details relating to the methods of utilizing the water resources of the country. Provision has been made for printing these by the following clause in the sundry civil act making appropriations for the year 1896-97:

Provided, That hereafter the reports of the Geological Survey in relation to the gaging of streams and to the methods of utilizing the water resources may be printed in octavo form, not to exceed 100 pages in length and 5,000 copies in number; 1,000 copies of which shall be for the official use of the Geological Survey, 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered to the House of Representatives, for distribution. [Approved June 11, 1896; Stat. L., vol. 29, p. 453.]

The maximum number of copies available for the use of the Geological Survey is 1,000. This number falls far short of the demand, so that it is impossible to supply all requests. Attempts are made to send these pamphlets to persons who have rendered assistance in their preparation through replies to schedules or who have furnished data. Requests specifying a certain paper and stating a reason for asking for it are granted whenever practicable, but it is impossible to comply with general requests, such as to have all of the series sent indiscriminately.

Application for these papers should be made either to Members of Congress or to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C.

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 35

OPERATIONS AT RIVER STATIONS, 1899.—PART I

By F. H. Newell

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

IRRIGATION REPORTS.

The following list contains titles and brief descriptions of the principal reports relating to water supply and irrigation, prepared by the United States Geological Survey since 1889:

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 126 pp.

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and report of work done during 1889.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo, 395 pp.

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889-90. Contains a description of the hydrography of the arid region and of the engineering operations carried on by the Irrigation Survey during 1890; also the statement of the Director of the Survey to the House Committee on Irrigation, and other papers, including a bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891; octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890-91. Contains "Report upon the location and survey of reservoir sites during the fiscal year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; "Irrigation in India," by Herbert M. Wilson. Illustrated by 39 plates and 180 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell; quarto.

No. 55, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 151, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No. 175, Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 53, September 9, 1892; quarto, 24 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a resume of the water supply and a description of irrigation by artesian wells. Illustrated by colored maps, showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-92, Part III, Irrigation, 1893; octavo, 480 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American irrigation engineering" and "Engineering results of the Irrigation Survey," by Herbert M. Wilson; "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnaissance in central Washington, by Israel Cook Russell, 1893; octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical conditions and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892-93, in two parts; Part II, Accompanying papers, 1894; octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W J McGee; "Natural mineral waters of the United States," by A. C. Peale; "Results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 35

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

PERATIONS AT RIVER STATIONS, 1899

A REPORT OF THE

DIVISION OF HYDROGRAPHY

OF THE

UNITED STATES GEOLOGICAL SURVEY

PART I

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

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DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, March 1, 1900.

SIR: I have the honor to transmit herewith a manuscript giving the results of operations at the river stations in the eastern portion of the country during the calendar year 1899, together with related data, for publication in the series of papers upon water supply and irrigation. The data for the central and western portions of the country will be transmitted as the succeeding numbers of the series.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

)PERATIONS AT RIVER STATIONS, 1899.

PART I.

INTRODUCTION.

The following pages contain descriptions of the river stations maintained during 1899 by the United States Geological Survey, together with tables of the average daily height of water and results of measurements of discharge. The rating tables constructed from the latter and applicable in general for the calendar year will be given at the end of the publication. Similar facts have been printed for the year 1896 in Water-Supply Paper No. 11, for 1897 in Water-Supply Papers Nos. 15 and 16, and for 1898 in Water-Supply Papers Nos. 27 and 28. The stations have been arranged in geographic order. A description of each station is given, together with all of the discharge measurements, followed by the tables of gage heights and ratings.

The material above noted consists essentially of the results of operations at the river stations, and forms the basis for computations of daily, monthly, and annual flow. In order to make these necessary computations considerable time and labor is involved and the resulting facts can be most clearly and concisely given by diagrams. The preparation of the computations and the diagrams necessitates unavoidable delays, and therefore it has been the custom to present the facts, such as are given herewith, as soon as possible after the close of the calendar year, so that the original data may be available at an early date to all who are concerned with their use. While these original figures are being printed the computations of final results are being prepared, and, with the illustrations, have in the past been made to form a part of the annual report of the Director of the Geological Survey. For example, the results for 1896, mentioned above, as given in Water-Supply Paper No. 11, are fully discussed in Part IV of the Eighteenth Annual Report; the original data for 1897, given in Water-Supply Papers Nos. 15 and 16, are published in final form in the Nineteenth Annual Report, Part IV, and the data for 1898, given in Water-Supply Papers Nos. 27 and 28, are published

in the Twentieth Annual Report, Part IV. In the same way the figures herewith given form the basis for conclusions being prepared for publication in Part IV of the Twenty-first Annual Report.

ACKNOWLEDGMENTS.

Most of the measurements herewith presented have been obtained through local hydrographers, a comparatively small part of the work having been conducted directly from the office of the Geological Survey at Washington. Acknowledgment is therefore due to each of these persons individually. Thanks should also be extended to individuals and corporations who have cooperated in various ways, either by furnishing readings of height of water or assisting in transportation. The following list gives the names of the resident hydrographers or persons cooperating, this being arranged alphabetically by States:

Arizona: W. A. Farish, civil engineer, Phenix.

California: J. B. Lippincott, civil engineer, Los Angeles.

Colorado: A. L. Fellows, civil engineer, Denver.

Georgia and Alabama: Prof. B. M. Hall, civil engineer, Atlanta, and Prof. W. S. Yeates, State geologist, Atlanta.

Idaho: N. S. Dils, civil engineer, Caldwell.

Kansas: W. G. Russell, Russell; Prof. E. C. Murphy, State University, Lawrence.

Maryland: Prof. W. B. Clark, State geologist, Baltimore.

Montana: S. M. Emery, director experiment station, Bozeman; Prof. Samuel Fortier, Bozeman; Prof. Fred. D. Smith, Missoula.

Nebraska: Prof. O. V. P. Stout, State University, Lincoln, assisted by Adna Dobson and Glenn E. Smith.

Nevada: L. H. Taylor, civil engineer, Golconda.

New Mexico: P. E. Harroun, civil engineer, Albuquerque.

North and South Carolina: Prof. J. A. Holmes, State geologist, Chapel Hill, North Carolina, assisted by E. W. Myers.

Texas: Prof. Thomas U. Taylor, State University, Austin.

Utah: Prof. Samuel Fortier, civil engineer, Corinne, assisted by J. L. Rhead and J. S. Baker; later, Prof. George L. Swendsen, Logan.

Virginia and West Virginia: Prof. D. C. Humphreys, Washington and Lee University, Lexington, Virginia.

Washington: Sydney Arnold, civil engineer, North Yakima; William J. Ware, civil engineer, Port Angeles.

Wyoming: A. J. Parshall, civil engineer, Cheyenne.

In a number of instances related data have been inserted, such, for example, as results of computation of daily flow at mill dams, made by local engineers, and data of river heights obtained from the United States Weather Bureau, or Corps of Engineers, United States Army. Reference to these facts, mainly unpublished, has been, or will be, made in other publications of this survey, and they are therefore placed in consecutive order for convenience of reference.

The methods of measuring the discharge of various streams and of

preparing the computations have been described on pages 18 to 30 of the Nineteenth Annual Report, Part IV, and on pages 20 to 22 of the Twentieth Annual Report, Part IV. The tables used in facilitating computations are also given on pages 29 to 32 of Bulletin No. 140.

CLASSIFICATION OF FIELD WORK.

In order to make a comprehensive study of the surface waters of the United States four classes of work are in hand:

1. Maintenance of long-record river stations.
2. Maintenance of short-record river stations.
3. Reconnaissance along streams.
4. Detailed reservoir surveys.

The long-record river stations are designed to show the influence of climatic fluctuations upon the volume of a river at a given locality. Only a few of these long-record stations can be maintained in any one State or section. Under this head are included only the localities where the conditions are highly favorable for accuracy of results as furnishing a standard of comparison. At such points especial care is taken to verify the gage readings and to make frequent measurements of discharge to give assurance that the rating table is correct. From the results obtained here it is possible to compare one year with another and ascertain which are years of high or low water or of medium flow.

The short-record river stations are established for the purpose of obtaining the flow at a given point for a short period. Each short-record station is discontinued as soon as the results are considered sufficient for probable industrial development. Reasonable care is taken to verify the results at these stations, but necessarily not the same refinement needed as in the case of the long-record stations.

Reconnaissance along important streams is systematically carried forward whenever the season is favorable, preferably during low water. Measurements of discharge are made wherever practicable during the progress of this work and observation of height maintained at some one point during the time of the reconnaissance. At important points level lines are run to obtain the fall, particularly where water power may be developed.

Reservoir sites are being examined and surveyed in various parts of the country whenever suitable localities are discovered by reconnaissance or are brought to attention in other ways. Contour maps are prepared of the lands to be flooded, showing the capacity of the reservoir at various depths. More detailed surveys are also made at the dam sites, and in some cases holes drilled down to and into the bed rock to ascertain the character of the foundations. From the information thus obtained estimates of cost are made. The matter is more fully described in the Twentieth Annual Report, Part IV, pages 25 to 43.

ACCURACY OF RESULTS.

In making the survey and examinations of the flow of streams in various parts of the United States the object in view has been to obtain facts of general application at a cost commensurate with the probable application of the results. It is recognized that with a given expenditure the number of measurements made will depend largely upon the accuracy and precautions employed, and the question at once arises as to what degree of precision should be sought. For example, to ascertain the flow of water at a certain point within 5 per cent of the actual flow may cost $10; within 3 per cent, $25; within 2 per cent, $100, and so on, the cost increasing in an ascending ratio as an approach is made to absolute accuracy. In the example given it is a matter of judgment whether to make measurements at a cost of $100 at ten points within 5 per cent of the flow, or at one point within 2 per cent. For general information concerning the hydrography of the country, such as that sought by this survey, it is obvious that the measurements at the ten points are better than the single measurement of greater accuracy; on the other hand, conditions may be imagined, for example, where water or power is being purchased, when the more expensive single measurement is important.

It is impracticable to assign definite limits to the degree of accuracy of the measurements and computations of river flow, since circumstances vary widely, but as a rule the limit has been set, as above stated, that they shall be within the range of ordinary practical application. The low-water flow or the floods of a given season are never repeated, being higher or lower in subsequent years. By continuing measurements through a decade the range within general limits is known, but may be passed during the succeeding decade. Great accuracy, therefore, in ascertaining the flow at any given time is not necessary for drawing general conclusions, as various assumptions must enter to modify the application of the facts.

In stating results of discharge measurements whole numbers have been used and decimals dropped from the figures obtained by computation. This rule is applied in all cases where the flow exceeds 10 cubic feet per second; where it is less than this decimals may or may not be used, although even here a false conception of accuracy may be given. In obtaining averages or totals representing the flow through considerable periods of time there may be some discrepancies involved through this omission of fractions, but it is not believed that the practical value of the work can be improved by introducing into the computation a higher degree of refinement than is possible or desirable in the field work.

EXPENSE OF MAINTAINING STATIONS.

During 1899 blank forms were sent to all resident hydrographers of the Geological Survey, with the request that they give a full description of each station, with reasons for its establishment and maintenance, together with an itemized statement of the costs incurred in making the measurements and in computing the results. These estimates have been compared with the actual expense incurred during the calendar year, and the results have been analyzed to ascertain what may be called the normal cost of maintaining river stations in various parts of the United States, and to ascertain which of the stations were requiring an expenditure out of proportion to the value of the results.

Whenever the cost of a station is excessive, a careful study of the necessity of that station has been made to determine whether the data obtained are of sufficient value to warrant the extra expenditure. In a few cases it has seemed advisable to discontinue stations on account of the expense of maintenance; but on the whole the result of the analysis has been gratifying, inasmuch as it has shown very few stations which could be considered excessively expensive, and in most of these cases the results obtained have been considered sufficiently valuable to warrant their continuance.

The conditions obtaining in the various parts of the country are so different that the annual cost of maintenance is not fairly comparable. This difference is due to several causes, the chief of which is the great distance between stations in some of the Western States when compared with stations in the Eastern States. This makes additional expense for railroad fare and also for services for the increased time spent in traveling. In most States passes are granted the hydrographers by the railroad companies when upon official business, but this is not true in all States. The beds of some rivers are rocky and permanent in character, necessitating only a few measurements a year, while others are sandy and shifting, requiring many measurements in order to construct discharge curves of any value. An extreme example of the latter case is the Gila River upon which measurements were made nearly every day in the year. The pay of the local observer varies with the distance he is obliged to travel daily to reach the gage.

For the reasons given above, the country has been divided into several sections according to the conditions at the stations. All of the stations in the States bordering on the Atlantic Ocean are considered in one class. These are 57 in number and are under the charge of 4 resident hydrographers. The rivers in the northern part of this section, as far south as Virginia, have as a rule been gaged at points where their beds are rocky, and require only about 4 measurements a

year in order to construct reliable discharge curves, as the curves constructed in the previous years need few changes. South of Virginia the gagings have been made where the beds of the rivers are for the most part soft and changeable, requiring from 6 to 8 measurements a year.

The normal cost of each gaging in the Atlantic States is $11.50. This includes every expense incident to the gaging, and may be divided approximately as follows:

Hydrographer's services in the field	$5.00
Hydrographer's services for computation	2.00
Services of assistant	.50
Cost of local transportation	1.00
Sundry expenses, including board, lodging, etc	3.00
Total	11.50

Hydrographers are obliged to travel, on the average, 200 miles for each gaging, but with few exceptions passes have been granted.

The pay of the observer averages $36 a year. This makes the total cost of an ordinary station in the Atlantic States $82 if 4 gagings are made during the year and $105 if 6 gagings are made.

The river stations in Kansas and Nebraska are in general under the same conditions, and are here considered together. The river beds are more or less changeable, so that, in order to obtain reliable discharge curves, it is necessary to make from 10 to 20 gagings a year at each station, with an average of about 12. The normal cost of each gaging is $12, divided in about the same proportion as in the Atlantic States. For the ordinary stations, therefore, the total cost of gaging for one year would be $144, and adding $40, the average cost of observers' services for one year in this section, gives $184 as the total cost of maintaining the station.

In Colorado the character of the river beds varies considerably in the different parts of the State. Some have a rocky, permanent bed, and others a soft, changeable one, requiring frequent gagings. For this reason the number of gagings required each year at the different stations varies from 2 to 10, with an average of about 6. The average cost of making a measurement is $13; the average cost of observations is $30, making a total cost of $108 for one year. The expense incurred in 1899 has not been as great as here mentioned, as fewer measurements per year have been made.

In Montana, at those stations under the charge of Prof. Fred. D. Smith, from whom reports have been received, the average cost of a gaging is found to be $10; and allowing 10 measurements a year and $30 for observations, the normal cost of maintaining a station for one year is $130.

In Wyoming the average cost of gagings is $30. Allowing 7 measurements a year and $26 for observations, this makes $236 as the normal

cost of maintaining a station for one year. This large expenditure is necessitated by the great distances traveled.

In Idaho the average cost of making a gaging is $20. Allowing 6 measurements a year at each station and $36 for observers, we have $156 as the normal cost of each station for one year.

In California we can say, roughly, that the average cost of a gaging is $30, and making 10 measurements a year; and paying $36 for observers, we have a total cost of $336 a year as the expense of maintaining a station.

These comparisons have been made in order that some idea might be obtained as to the proper cost of maintaining stations. If the cost of any particular station is much higher than the normal cost of stations in that section, it is important that a careful study be made to determine whether or not the measurements are of such value as to warrant the additional expenditure. If not, the station should be discontinued.

DETERMINATION OF DISCHARGE FROM SLOPE.

At various times attempts have been made to obtain data as to slope or fall per mile of the water surface of various rivers, in order to use this factor in estimates of the flow of the stream, and thus make comparison with the discharge as measured by current meters. It has been quite difficult, however, to do this, and the results have been somewhat unsatisfactory, owing to the uncertainty in determining the slope of the stream, considerable latitude of judgment being possible.

Careful leveling along the banks of most streams of moderate size shows that the water surface is alternately approximately level, then has a distinct fall, and again is nearly level; in other words, as expressed in the South, the stream consists alternately of pools and riffles. These may be imperceptible to the eye, but are detected by careful leveling. In determining the slope of the stream the question therefore arises as to whether this shall be determined for the immediate proximity of a given cross section, either at a pool or a riffle, or be taken to include a number of these, and thus extend several thousand feet or even several miles. On the selection of this distance depends, to a large extent, the slope of the stream, the amount varying within wide limits.

The desirability of again taking up this matter was brought to the attention of this office in July, 1899, by Mr. Desmond FitzGerald, chief engineer, to the special commissioners of the Chicago Drainage Canal. Instructions were sent to each field party to endeavor to make such measurements wherever it could be done without notable increase of cost. So many practical difficulties were encountered it has been found that for these observations to have value they should be made by a

field party especially equipped for the purpose and provided with appliances such as are rarely at hand in making ordinary meter measurements.

A few such measurements were made during the past season by different hydrographers, and they will now be considered. The following abbreviations will be used in this connection: D=discharge; A=area, in square feet; V=velocity, in feet per second; W=width, in feet, or practically wetted perimeter; $R=\frac{A}{W}$, hydraulic mean radius; S=slope; n=coefficient of roughness. Kutter's formula has the form $V=C\sqrt{R\,S}$, in which C is a constant to be found.

Etowah River at Canton, Georgia.—On September 5, 1899, B. M. Hall made a survey of this river to find the correct value of n for a 1,500-foot section along the stream. After measuring 1,500 feet, running levels, and placing temporary gage at upper point, he did not have time to make a discharge measurement, but applied the slope to the measurement made August 28, 1897, when the following were found: Gage height, 0.30 foot; area, 423 square feet; mean velocity, 1.061 feet per second; discharge, 449 second-feet. The slope was 0.06 foot in 1,500 feet=0.00004. W=115; therefore $R=\frac{423}{115}=3.68$, and $\sqrt{R\,S}=0.012132$. Substituting in the formula $V=C\sqrt{R\,S}$, we get C=87.4, and from the table in Trautwine, 17th edition, page 276, we find n=0.022.

Loup River at Columbus, Nebraska.—A series of slope measurements to determine the value of n were made by Glenn E. Smith, under the direction of Prof. O. V. P. Stout, of the University of Nebraska, at the gaging station on Loup River. Gage heights were taken on two gages, the auxiliary gage being placed 1,200 feet downstream from the main gage rod. The following were the three observations:

Measurements of Loup River at Columbus, Nebraska.

Date.	Main gage.	Lower gage.	Width.	Area.	Mean velocity.	Discharge.	R
1899.	*Feet.*	*Feet.*	*Feet.*	*Square feet.*	*Feet per second.*	*Second-feet.*	
Sept. 3	4.40	3.30	525	875	2.17	1,902	1.67
Sept. 17	4.40	3.31	525	826	2.23	1,840	1.57
Oct. 5	4.60	3.52	525	953	2.52	2,402	1.81

The following are the computations for the three days: September 3: $S=\frac{1.1}{1,200}=0.00093$; R=1.67; V=2.17. Substituting in the formula $V=C\sqrt{R\,S}$, we obtain C=55.0, and from the table n=0.028.

September 17: S=0.00091; R=1.57; V=2.23. C, therefore, =59.0 and n=0.026.

October 5: S=0.00090; R=1.81; V=2.52. C is found to equal in this case 62.3 and n = 0.026.

Niobrara River at Fort Niobrara, Nebraska.—The following table shows the results of similar measurements made on this river under the direction of Professor Stout. All gage heights are referred to the zero of the main gage. The upper auxiliary gage is 600 feet above and the lower auxiliary gage 600 feet below the main rod.

Measurements of Niobrara River at Fort Niobrara, Nebraska.

Date.	Main gage.	Upper gage.	Lower gage.	Area.	Mean velocity.	Discharge.	Width.	R
1899.	*Feet.*	*Feet.*	*Feet.*	*Square feet.*	*Feet per second.*	*Second-feet.*	*Feet.*	
Aug. 30	1.35	2.32	0.60	196	3.57	700	154	1.27
Sept. 13	1.15	2.20	.60	200	3.47	695	154	1.30
Sept. 26	1.05	2.10	.40	198	3.70	732	154	1.29
Oct. 7	1.15	2.05	.55	215	3.61	776	154	1.40
Oct. 20	.80	2.08	.30	199	4.27	849	154	1.29

As there were three gages read, three different slopes can be determined, as follows: Between the upper and middle gage, between the middle and lower gage, and, finally, between the upper and lower gage. They do not correspond well, as shown in the table immediately following, the slope between the middle and lower gage being constantly less than the slope between the upper and middle gage, and of course the slope between the upper and lower gage is the mean between them.

Comparison of slope measurements at Fort Niobrara, Nebraska.

Gage rod.	Aug. 30.	Sept. 13.	Sept. 26.	Oct. 7.	Oct. 20.
Upper and middle	0.00161	0.00175	0.00175	0.00150	0.00213
Middle and lower	.00125	.00091	.00109	.00100	.00083
Lower and upper	.00143	.00133	.00142	.00125	.00148

The following determinations of the values of C and n are based on the slope as found by the readings on the upper and lower gages. The computations are not carried out, but the results are shown in the following table:

Table showing values of C and n.

	C	n
1899.		
August 30	84.1	0.018
September 13	83.5	.018
September 26	86.8	.018
October 7	86.5	.018
October 20	97.7	.016

One comparison is made between the values of C and n as determined by considering the three different slopes for a single measurement, and for this purpose the gaging on September 13 is used. On this date R=1.30; V=3.47; S, for upper and middle gage, =0.00175; C is found to equal 73.5 and n 0.020. For middle and lower rod, S=0.00091, and C, therefore, =101.0, and n= 0.015. The following table shows these values of C and n for the three slopes on September 13:

Table showing values of C and n on September 13, 1899.

Gage rod.	C	n
Upper and middle	73.5	0.020
Middle and lower	101.0	.015
Lower and upper	83.5	.018

For comparison with results obtained on September 13 it is assumed that the slope determined was made between the upper and lower gages 0.00133. Substituting in Kutter's formula the value of n, as found from the determinations of the slope of the upper and middle rod, we get a discharge of 840 second-feet. Assuming the same slope as above—that is, between the upper and lower rod—and taking the value of n as found between the middle and lower rod, =0.015, and substituting again in Kutter's formula, we get a discharge of 610 second-feet. These latter results are not satisfactory. In this case, with 0.015, 0.018, 0.020 as the three assumed values of n, we get discharges of 610, 695, and 840 second-feet, respectively. The measured discharge, as determined by current meter, for this date was 695 second-feet.

Readings on slope gages were taken for a short period in 1896 on Frenchman River, at Palisade, Nebraska, as shown in the Eighteenth Annual Report, Part IV, page 198, and in Water-Supply Paper No. 11, page 56.

Bear River at Battlecreek, Idaho, and Collinston, Utah.—Measurements of the fall of the surface of Bear River at Battlecreek, Idaho, and at Collinston, Utah, were made by Prof. Samuel Fortier. Stakes were driven into the channel of the stream about 10 feet from each shore line, at points 100 feet below and 100 feet above the cable suspended across the stream. These four stakes were pointed on the top and driven about 1.5 inches below the surface of the water. A small wire nail was driven into the top of each stake until level with the surface of the water, allowance being made for the pulsation of the surface. The elevations of the tops of these nails were then carefully ascertained with a level.

At Battlecreek, Idaho, the bed of Bear River consists of clay near the right bank, small cobblestones in the center, and gravel and pebbles near the left side. The banks are somewhat irregular. The fall, $S = 0.00062$; water area, A = 443 square feet; mean velocity,

= 2.36 feet per second; hydraulic mean radius, R = 2.31; wetted rimeter, 191 feet; n = 0.027; C, in Chezy's formula, 62.58; the disarge, D, was 1,046 second-feet.

At Collinston, Utah, the bed of Bear River consists of cobble rock ones and bowlders. The fall was found to be, S = 0.00131; A = 427 uare feet; V = 2.333 feet per second; R = 1.58; wetted perime-r, 270; n = 0.029; C, in Chezy's formula, 51.28; the discharge, 996 econd-feet.

ESTIMATION OF DISCHARGES AT MILLDAMS.

On rivers which, like those in New England, have been used for vater power, it is often difficult to find a section where measurements vith the current meter can be readily made. The milldams placed at hort intervals back up water or introduce conditions unfavorable to lirect measurement of flow. On the other hand, the facilities at the nilldams are often excellent for noting the height of water, as gages re frequently maintained in the interest of the mill owners. In a umber of cases where controversies have arisen concerning water ower or there now exist contracts for the division of the available low, elaborate computations have been made showing the discharge ver the dams and through the various openings leading to the mill vheels. Occasionally these computations of flow are sufficiently xtensive to have general interest in showing the run-off from a given rainage area, but more often the results are fragmentary.

Probably the earliest and most thorough determination of the flow f a river by estimating the amount taken by mills and passing over e dam is that begun by Mr. J. B. Francis over a half century ago the Merrimac River at Lawrence, Massachusetts. This may be nsidered as the model of all attempts of this kind. Similar comitations, based upon the Francis formula, have been made on other ew England streams, notably on Connecticut River at Holyoke, Maschusetts, and on Kennebec River at Waterville, Maine. The unrtainty as to the application of certain constants or factors is such at estimates of this kind are apt to be misleading unless made by an gineer thoroughly familiar not only with the fundamental data, but ith all of the varying local conditions. In order to make computaons of daily discharge and correction for changes in the conduits verting water above the dam, it is necessary to maintain records of rious facts besides the height of water. To facilitate the keeping of ch records blanks have usually been prepared with a space for tering the depth of water on the crest of the dam, and the length of is in linear feet—especially when modified from day to day by the e of flashboards. These records of depth are usually made night d morning, and occasionally are noted every two or three hours roughout the day. Besides these, spaces are provided for reading e height of water at the headrace and tailrace of each mill, giving ta for the working head on the water wheels. The number of

wheels, the size and kind, the number of hours operated, and other facts concerning their use are also given, in order to compute the probable flow through each wheel and add this to the amount passing over the dam. Corrections must usually be introduced for leakage and for the amount escaping through waste ways. It is evident that for any given locality with a number of mills the recording of the facts not only requires care and time, but some display of intelligence on the part of the workmen, to whom the recording is necessarily intrusted.

All of the conditions above noted, and the uncertainty regarding accuracy of the constants used in the computations, tend to make the estimates not only complicated, but introduce more or less doubt as to the value of the results. This is particularly true when there are a number of mills taking water from the impounded river and in seasons of low water when the greater proportion passes through the mill wheels. At a number of localities where such estimates are made all of the water enters the mill races during the summer, leaving the crest of the dam dry.

Estimates of the flow of streams at milldams have been recently extended to certain streams in New York, most of which are tributary to Mohawk River. These were begun in October, 1898, by Mr. George W. Rafter, who was at that time employed on special water-supply investigations for the United States Board of Engineers on Deep Waterways. This board, consisting of three engineers designated by the President, one from the Engineer Corps of the United States Army, one from the Coast and Geodetic Survey, and one from civil life, was authorized by act of Congress approved June 4, 1897 (30 Stat. L., 50). Its purpose is to make surveys and examinations, including estimates of cost of deep waterways between the Great Lakes and the Atlantic tide waters, as recommended by the report of the Deep Waterways Commission, transmitted to Congress on January 18, 1897.[1] The work of the board was continued by the act of July 1, 1898 (30 Stat. L., 636), providing that estimates should be prepared for cost of waterways 21 and 30 feet in depth, and by act of March 3, 1899 (30 Stat L., 1109).

Under the direction of Mr. Rafter about 20 stations for studying sources of supply for deep waterways have been established in the State of New York, the locations of which are shown by fig. 12, on page 79 of Part IV of the Twentieth Annual Report of the Geological Survey.

In each case these points of measurement are at dams built to furnish power for mills, or constructed by the State for supplying water to the Erie Canal and its feeders. The dams thus employed as weirs are of various sections and materials. A few are of stone, solidly built, but most are of timber. Some of the latter are tight, while others

[1] *Report of* the United States Deep Waterways Commission, prepared at Detroit, Michigan, *December 18-22, 1896*, House Doc. No. 192, Fifty-fourth Congress, second session.

leak, and in these cases estimates have been made of the quantity flowing through the dam. Usually the estimate was made at the establishment of the river station, and leakage was considered as being constant. In a few instances current-meter measurements were made of the leakage, and the quantity found was used as a correction in the computations.

In examining the dams in the rivers it was found that many of them were irregular in longitudinal profile of crest. In a number of cases they were so repaired as to give a horizontal crest, but at several localities it was impossible to eliminate this irregularity. In these cases a careful profile of the crest was plotted and divided into parts in such a way that the crest of each portion could be considered as horizontal without introducing serious errors. Computations were then made of the flow through each section irrespective of its neighbor, and the quantities in all sections were added together to give the total flow over the dam. These computations were made for different heights of water and plotted graphically with the head on the crest in feet as ordinates and the discharge in second-feet as abscissas. A smooth curve was then drawn through these points, from which discharges have been read for various heads. In a number of instances these curves have been revised, using coefficients determined at a later time.

In order to compute the discharge over dams, it is necessary to make certain assumptions or employ coefficients obtained by experiment. The coefficients for determining the flow over broad-crested weirs are somewhat uncertain, especially with high heads. The most reliable coefficients are those determined by experiments of Bazin's, published in the Annales des Ponts et Chaussées.[1] In those experiments the head on the crest of the weir never exceeded 1½ feet. As the coefficients over broad-crested weirs vary considerably with the head, it is a matter of judgment what coefficients to apply when the heights exceed those experimented upon by Bazin. Profiles of the dams as constructed in the river seldom correspond exactly with the profile for which the coefficients were determined. For each case it is necessary to assume an experimental profile which corresponds most closely with the measuring dam. In order to eliminate these two sources of error, experiments were instituted at Cornell University to determine coefficients for experimental flat-crested weirs as used by Bazin with heads on crest as high as 6 feet, and also upon other forms of weirs corresponding to those of the dams over which measurements are made.[2]

In making these experiments the first question that arose was to determine the actual quantity of water flowing over the experimental

[1] Annales des Ponts et Chaussées, Ire partie, 1898, 2e Trimestre, No. 24, p. 151 to 264. Expériences Nouvelles sur l'Écoulement en Déversoir (6e article), par M. H. Bazin, Inspecteur général des Ponts et Chaussées.

[2] On flow of water over dams, by George W. Rafter: Proc. Am. Soc. Civ. Eng., March, 1900, Vol. XXVI, No. 3, pp. 226-312.

weirs. To determine this a sharp-crested weir was constructed of exactly the same dimensions as that experimented upon by Bazin, for which he (Bazin) has published accurate coefficients. Bazin's coefficients for this sharp-crested weir were determined only for small heads.

In order to obtain accurate coefficients for sharp-crested weirs for a greater head, another weir of shorter length was placed below the Bazin weir in the same flume. Knowing the actual quantity flowing over the Bazin weir, and carrying the height on crest to the limit of the Bazin experiments, it was possible to determine coefficients for sharp-crested weirs for heads as high as about 6 feet. The coefficients determined from this second sharp-crested weir were then used to find the actual quantity of water flowing over all experimental sections used thereafter. Gates were so arranged that the quantity of water flowing in the flumes could be varied at will, and starting with a high head the water was gradually reduced in quantity, reducing thereby the head on the crest to zero. The gates were allowed to remain in each of the eight or ten positions from ten minutes to an hour, so that the flow for that interval was constant. By reading the head of the sharp-crested weir, the water flowing at the given width of gate opening could be determined. At the same time the head on the experimental weir was read and, noting the quantity, the coefficients computed for use in the formula $q = CLH^{\frac{3}{2}}$. In this formula $C = m\sqrt{2g}$ of Bazin's formula. One run was made for each experimental weir, and eight or ten points of the curve were determined. The experimental weir, which was constructed of wood, was then torn out and one of another section put in its place. When all worked well it required one day for experimentation on each section. Experiments were made on forms of weirs corresponding to nearly all of the dams over which the flow was measured.[1]

Practically all the computations of the flow of streams made by the Board on Deep Waterways had been completed before these coefficients for high heads were determined, so that Bazin's coefficients were used instead of the Cornell coefficients, although in Mr. Rafter's opinion the Cornell coefficients would be more accurate. It was proposed to recompute back records, using the Cornell coefficients, but lack of time and funds have prevented. The monthly totals have, however, been approximately corrected. There are some discrepancies between Bazin's and the Cornell coefficients, even for low heads, which are attributed to difference in the construction of the experimental weirs and the consequent action of the air cushion. It is possible that the conditions in the Cornell experiments are nearer those in actual dams.

As has been stated, most of the measuring stations are dams furnishing power for mills, and of course a large quantity of water passes

[1] On flow of water over dams, by George W. Rafter: Proc. Am. Soc. Civ. Eng., March, 1900, *Vol. XXVI*, No. 3, pp. 236-319.

through the mill race and wheels and not over the dam. In order to determine this quantity of water, gages are used, as before noted, above the wheels in the headrace and below the wheels in the tailrace, so that by simultaneous readings the head on the wheels at any time may be determined. The size and type of wheels used in each mill and the dimension of the gates were ascertained. In many cases, especially in the case of new wheels, records of careful ratings made at Holyoke, Massachusetts, were obtained for the particular wheels installed in the mills. Where these could be obtained they were used to determine the flow through the wheels. In other cases it was necessary to rely upon the figures published in the trade catalogues for the quantity of water flowing through the various wheels at the various heads, although these quantities are not always accurate. In some of the headraces there are overflows which must be taken into account as the head increases, and over which the flow is somewhat uncertain. When the State dams were used, as in most cases, in New York the flow through the canal feeders was measured once and assumed to be constant thereafter.

The following table gives a list of the New York streams, the flow of which has been computed as described above. Their drainage areas are also given. The numbers in the first column are those shown in the Twentieth Annual Report, Part IV, fig. 12, where the location of the points of observation is given.

Streams measured by the United States Board of Engineers on Deep Waterways.

No.	Streams.	Locality.	Drainage area.
			Sq. miles.
1	Seneca River	Baldwinsville	3,103
2	Oswego River	Fulton	4,916
3	Chittenango Creek	Bridgeport	307
4	Oneida Creek	Kenwood	59
5	Wood Creek	Near mouth	.....
6	Fish Creek, west branch	McConnellsville	187
7	Fish Creek, east branch	Above Point Rock	104
8	Salmon River	About 1 mile above falls	191
9	Mohawk River	Ridge Mills	153
10	Ninemile Creek	1 mile below Stittville	63
11	Oriskany Creek	State Dam, Oriskany	144
12	do	Coleman	141
13	Sauquoit Creek	New York Mills	52
14	West Canada Creek	Middleville	519
15	Mohawk River	Little Falls	1,306
16	East Canada Creek	Dolgeville	256
17	Garoga Creek	3 miles above the Mohawk	81
18	Cayadutta Creek	Below Johnstown	40
19	Schoharie Creek	State Dam, Fort Hunter	947
20	Mohawk River	State Dam, Rexford Flats	3,385
21	Hudson River	Mechanicville	4,500
22	do	Fort Edward	.....
23	Schroon River	Warrensburg	563
24	Black River	Watertown	1,389

The results obtained at the localities named above, from September, 1898, to May, 1899, inclusive, as computed by Mr. George W. Rafter, are given in the following table. The numbers in the first column of the preceding table refer to the same numbers in this table:

Estimated monthly discharge of various New York rivers in cubic feet per second.

No.	1898.				1899.				
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
1	.....	.....	3,137	2,689	2,851	1,769	3,875	4,543	2,568
2	.....	.....	6,220	5,300	6,150	4,075	7,830	11,000	6,586
3	129	320	550	530	600	450	711	820	230
4	.....	76	95	75	97	79	126	160	58
5	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	108	300	340	180	385	170	530	1,040	215
7	250	310	380	201	209	251	342	751	295
8	.....	.....	490	315	522	200	468	2,220	605
9	.....	324	356	216	382	199	422	952	275
10	308	98	92	135	225	85	210	340	47
11	.....	325	327	327	295	291	342	466	119
12	.....	.....	.....	.....	.....	.....	.....	.....	.....
13	27	56	57	57	58	58	111	127	38
14	.....	1,071	1,125	922	1,028	1,422	1,058	3,365	1,456
15	2,378	2,493	2,891	2,036	2,753	1,510	3,757	8,102	2,651
16	638	581	689	564	816	439	519	1,978	633
17	.....	140	190	77	43	47	160	500	99
18	16	64	91	44	39	31	74	251	31
19	409	1,422	2,447	1,853	2,584	2,224	4,072	4,380	858
20	.....	.....	.....	4,550	5,850	4,000	9,250	17,400	4,150
21	3,872	7,895	9,243	5,436	6,068	5,258	9,618	23,645	9,752
22	.....	.....	.....	.....	.....	.....	.....	.....	.....
23	166	263	464	783	606	478	564	2,877	3,150
24	1,744	3,607	4,510	2,752	4,704	2,381	5,112	14,172	5,840

TURBIDITY.

Many attempts have been made to determine the amount of silt carried by water in suspension, but as a rule these necessitate elaborate operations of filtering, drying, and weighing. One of the most convenient methods for field work is that recently applied by Mr. Allen Hazen, who has prepared an arbitrary scale dependent upon the degree of opacity of the water. Observations of turbidity are taken by putting a stick into the water under examination and noting the distance beneath the surface at which a given object—usually a small wire—can be seen. The turbidity is then read from a scale graduated on this stick. This is most conveniently accomplished by having a second or smaller stick placed in front of the first, the end of which is brought to the water line at a point where the wire can just be seen. Upon removing the two together the position of the smaller stick on the scale gives the turbidity.

Observations are taken in the open air, as too high results are obtained under a roof, even with good light. They preferably should be made in the middle of the day, and not in direct sunlight. In case the sun is shining the observer can stand so that his shadow covers the water immediately above the stick and wire. The observer stands erect with his feet a little above the water, although some variation in this respect does not materially influence the results.

The stick should be about 5 feet long and five-eighths of an inch square. A platinum wire should be inserted at a point about 1 inch from the end at rightangles and projecting 1 inch. This wire should be about 0.04 inch in diameter. The stick is then graduated, the figures being inversely proportional to the distances from the wire, 1.00 coming at 1 inch. The following table gives the graduations up to 50 inches:

Scale of turbidity.

Turbidity.	Inches.	Turbidity.	Inches.	Turbidity.	Inches.
2.00	0.50	0.10	10.00	0.05	20.00
1.50	.66	.09	11.11	.04	25.00
1.20	.83	.08	12.50	.03	33.30
1.00	1.00	.07	14.30	.02	50.00
.50	2.00	.06	16.70	.01	100.00

MEASUREMENTS AT RIVER STATIONS.

KENNEBEC RIVER AT WATERVILLE, MAINE.

This river has been described by Prof. Dwight Porter in the Nineteenth Annual Report, Part IV, pages 65 to 84, the general location of the stream being shown on Plate IX. Computations of discharge at Waterville, Maine, were made by Mr. Sumner Hollingsworth from about 1892 to the time of his death, which occurred June 27, 1899. Additional figures have been furnished by Mr. James L. Dean, engineer of the Hollingsworth & Whitney Company, a slightly different system of computation being employed by Mr. Dean, as it has been impracticable to introduce the corrections made by Mr. Hollingsworth, the principles upon which he worked not being fully recorded. Corrections were probably made for loss of head in the tailrace and leakage. The figures of daily discharge from 1892 to August 31, 1898, as computed by Mr. Sumner Hollingsworth, are given in Water-Supply Paper No. 27, page 14; those subsequent to the above date have been furnished by Mr. Dean.

Concerning those for 1899, Mr. Dean states that the figures subsequent to May 1 have not been computed with the same care as previous records, but they are believed to be correct for most practical purposes. The discharge over the dam was computed as usual, but that from the wheels was not estimated separately for each day, using the head of each wheel, and the speed of rotation, as heretofore done. Instead of this the average performance was taken. A comparison of gage readings and water discharges shows little connection, as flashboards are used on the dam. The Sunday flow is also irregular, as the mill at Waterville is sometimes operated Saturday night, drawing the water from the pond, so that there is no flow except leakage on Sunday. During the season of low water there is usually less passing on Sunday than on week days, as at many mills on the river the dams are closed *in order to fill* the ponds.

Daily discharge in second-feet of Kennebec River at Waterville, Maine.

1898.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2,475	2,539	4,170	20,385	36,048	14,341	4,385	3,790	2,477	2,691	6,382	3,752
2	2,284	2,955	4,188	16,556	39,372	13,776	4,343	2,707	2,489	2,862	5,182	3,740
3	2,222	2,687	5,648	13,871	38,301	10,900	3,440	2,887	2,453	2,180	4,691	3,667
4	2,715	3,090	5,163	12,143	37,358	8,791	3,490	2,833	1,437	1,831	4,115	1,747
5	2,771	2,775	2,997	10,830	37,730	9,846	4,343	2,809	2,510	1,865	3,467	3,336
6	3,431	3,068	4,094	10,150	37,569	10,301	4,272	3,712	2,392	2,119	3,231	3,227
7	1,807	3,475	5,070	7,080	31,580	9,189	4,477	3,252	3,093	1,570	3,880	3,221
8	4,826	2,994	5,033	6,563	29,880	9,098	4,203	4,374	3,073	1,209	3,675	3,262
9	5,434	3,744	4,767	7,472	28,753	12,541	5,464	4,218	3,018	1,150	4,133	2,995
10	4,492	3,154	4,623	10,457	25,636	14,318	1,745	4,017	3,042	961	3,351	2,635
11	3,025	3,829	5,329	15,299	22,059	12,086	4,111	3,048	3,050	1,585	5,332	1,792
12	3,286	3,317	6,752	19,848	21,899	11,322	4,484	3,413	3,057	1,731	5,856	3,268
13	3,240	3,680	8,397	44,854	24,042	11,003	4,267	2,927	2,505	1,585	4,896	2,235
14	3,287	3,912	9,880	47,141	34,332	10,777	3,776	1,130	1,913	1,288	3,332	1,873
15	4,909	4,026	11,534	50,381	32,988	12,514	4,327	3,443	1,480	1,299	3,465	1,888
16	3,717	4,042	12,816	49,415	27,500	11,295	3,994	2,499	1,560	3,665	3,264	1,883
17	3,891	3,764	12,215	47,112	24,756	10,584	3,611	2,560	1,530	6,031	3,490	2,160
18	3,453	3,221	11,918	47,321	23,440	9,478	3,896	2,491	1,570	5,055	3,698	1,723
19	3,460	3,267	12,484	44,700	23,153	9,196	3,938	2,622	1,607	4,454	5,018	2,315
20	3,505	2,885	13,218	39,327	20,592	11,129	3,747	2,526	1,876	3,264	8,798	2,447
21	3,893	3,172	14,580	36,671	19,088	10,855	3,835	913	2,223	2,872	8,935	2,560
22	4,614	3,764	17,177	33,789	18,570	9,950	5,038	3,425	1,851	2,690	8,046	2,274
23	2,542	2,133	16,615	30,702	17,073	8,334	3,871	2,866	1,888	6,036	7,184	2,778
24	2,321	3,437	15,987	34,352	15,277	9,483	3,418	3,425	1,916	6,318	6,007	3,013
25	2,866	4,352	17,812	52,119	15,993	8,864	3,747	2,849	3,689	4,924	7,811	2,489
26	2,032	3,933	17,029	45,520	15,589	7,508	3,879	4,432	5,443	4,288	7,923	2,471
27	3,136	3,653	16,500	38,083	15,639	5,267	3,385	4,218	4,788	6,514	10,037	2,761
28	2,905	4,387	18,928	37,354	14,611	4,326	4,189	3,940	3,581	15,319	3,672	2,464
29	2,727	.....	19,762	33,652	16,632	5,689	3,444	3,396	3,778	11,127	2,758	2,499
30	1,738	.....	17,711	31,767	16,962	6,715	3,204	3,555	3,247	9,229	3,723	2,067
31	2,607	.....	27,432	.....	16,298	.....	2,832	2,857	.....	7,672	.....	2,178
Mean.	3,213	3,402	11,287	29,833	25,120	9,983	3,908	3,133	2,618	4,047	5,178	2,620

1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2,529	2,458	3,382	6,343	41,348	13,292	6,386	4,020	1,985	1,200	1,405	1,405
2	2,202	2,198	3,047	6,114	39,433	12,783	4,924	3,800	1,985	1,297	2,759	1,405
3	2,274	2,187	3,333	6,080	36,354	10,632	5,164	4,380	1,403	1,445	4,025	1,000
4	2,159	2,163	3,324	5,945	36,864	11,573	3,178	4,088	1,695	1,269	4,025	2,855
5	2,452	1,580	1,960	6,125	30,725	12,183	5,080	4,380	1,985	1,823	1,636	3,476
6	2,451	2,509	3,331	6,135	30,358	11,076	4,943	2,865	1,695	1,303	3,258	3,040
7	2,449	2,173	3,563	6,343	30,025	10,516	5,264	4,788	1,985	1,330	3,039	1,950
8	1,739	2,071	3,516	6,859	29,257	11,679	5,164	4,968	1,985	800	2,565	1,985
9	2,757	2,057	3,502	7,441	26,688	12,450	3,836	4,234	2,275	1,069	2,275	1,695
10	2,519	2,152	3,428	8,904	24,760	12,450	4,943	4,015	1,646	755	2,058	900
11	2,400	2,141	3,357	9,472	22,244	10,638	4,943	4,015	2,275	561	1,695	1,405
12	2,386	2,244	2,302	9,272	20,182	10,213	4,832	3,880	1,985	1,564	1,200	1,105
13	2,404	2,348	3,353	10,999	18,665	6,024	4,943	2,420	1,985	1,822	1,478	1,985
14	2,436	1,964	3,423	19,504	19,543	7,006	5,738	3,880	1,985	1,245	1,985	4,898
15	1,678	1,844	3,624	22,940	14,849	6,693	4,943	3,400	1,985	924	1,985	4,501
16	2,731	2,392	3,773	37,830	14,944	7,432	4,943	3,400	1,695	1,405	1,985	4,608
17	2,439	2,434	3,501	30,458	17,275	5,881	4,832	3,120	1,200	1,695	1,768	2,400
18	2,631	2,727	3,253	30,190	15,044	6,707	5,180	3,500	1,405	1,405	1,695	2,638
19	2,434	2,198	1,960	36,964	15,044	7,274	5,180	2,560	1,985	1,115	1,100	1,985
20	2,628	2,915	3,320	41,348	15,597	6,453	4,832	1,670	2,275	1,405	1,405	2,565
21	2,440	2,734	3,080	34,395	16,162	7,006	5,424	2,634	2,275	1,115	2,275	2,275
22	2,094	2,744	2,778	30,090	18,296	7,237	6,210	3,220	2,565	918	1,695	2,275
23	2,709	2,451	2,711	38,466	17,275	7,237	5,588	2,840	2,275	1,405	2,058	2,265
24	2,154	2,745	2,837	45,172	15,872	9,432	6,368	2,534	1,500	1,400	1,985	1,900
25	2,435	2,929	2,770	41,348	15,791	5,593	5,785	2,180	1,885	1,105	1,985	1,900
26	2,450	1,420	2,030	42,736	11,380	7,274	5,785	2,158	1,615	1,115	1,400	1,900
27	2,454	3,039	2,786	45,422	12,539	7,237	5,424	1,620	1,320	1,115	1,405	2,275
28	2,434	3,362	2,740	39,533	12,203	6,849	5,785	2,120	2,104	1,115	1,695	2,775
29	1,245	.....	2,998	41,248	13,027	7,006	4,088	2,560	2,116	1,000	1,695	1,695
30	2,513	.....	3,962	29,200	13,535	6,386	2,400	2,100	2,100	1,115	1,100	1,405
31	2,453	.....	6,820	.....	12,783	.....	4,020	2,380	.....	1,115	.....	1,405
Mean	2,357	2,364	3,218	23,429	21,228	8,807	5,036	3,217	1,906	1,224	2,021	2,254

ANDROSCOGGIN RIVER AT RUMFORD FALLS, MAINE.

This river receives the drainage from the Rangeley and other lakes, near the border line between Maine and New Hampshire. It flows in a general southerly and southeasterly direction, descending with rapid fall and furnishing considerable power. It is described by Prof. Dwight Porter in the Nineteenth Annual Report, Part IV, pages 84 to 97. The discharge at Rumford Falls since 1892 has been ascertained by Mr. Charles A. Mixer, resident engineer of the Rumford Falls Power Company. Figures of daily discharge up to the end of December, 1895, have been printed in Water-Supply Paper No. 27, pages 11 to 14. The table is continued for the years 1896 to 1898 in the Twentieth Annual Report, Part IV, pages 67 to 69. These figures are obtained by adding the actual measured quantities passing through the wheels and the computed flow over the dam, using the customary Francis weir formula.

Mr. Mixer has prepared a table giving the departure of the precipitation of 1899 from the normal, which is taken at 43.41 inches, showing that for this latter year there was only 31.58 inches, or a deficiency of 27 per cent. This emphasizes the importance of water storage, not only for such rare periods, but also for equalizing the fluctuations from month to month during every year. The lowest monthly run-off, 0.71 inch in depth, was in August, the month of greatest evaporation. At this time the run-off was 0.07 inch more than the precipitation. The lowest daily discharge for the year, 1,124 second-feet, was 0.48 second-foot per square mile. The total annual run-off averages 53 per cent of the total precipitation as measured at Rumford Falls; but in 1899 the percentage rose to 59, the increase presumably being due to storage. The records of precipitation have not been kept for a sufficiently long period to give a wide range in fluctuation, but, judging from the effect on the wells, there has been no such period of drought for from fifty to seventy-five years.

Comparison of rainfall at Rumford Falls, Maine.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Normal	3.23	4.28	3.55	2.99	3.92	3.63	4.48	3.49	3.34	2.78	4.74	2.98
1899	3.18	2.56	5.89	1.50	1.59	2.27	4.71	.64	3.00	2.05	1.94	1.95
Normal accumulation	3.23	7.51	11.06	14.05	17.97	21.60	26.08	29.57	32.91	35.69	40.43	43.41
1899 accumulation	3.18	5.74	11.63	13.13	15.02	17.29	22.00	22.64	25.64	27.69	29.63	31.58
Accumulated excess	.....	.....	.57	.....	.....	.....	.....	.....	.....	.....	.....	.....
Accumulated deficiency	.05	1.77	.....	.88	2.95	4.31	4.08	6.93	7.27	8.00	10.80	11.83

Daily discharge in second-feet of Androscoggin River at Rumford Falls, Maine, for 1899.

[Drainage area, 2,330 square miles.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2,396	1,802	1,908	2,029	24,057	3,773	3,224	1,321	1,359	2,130	2,186	1,230
2	2,441	1,861	1,955	2,098	24,057	3,495	3,000	1,337	1,453	1,794	2,172	1,247
3	1,952	1,736	1,977	1,998	22,408	3,383	2,900	1,402	1,247	1,709	2,865	1,700
4	2,124	1,895	1,791	1,973	19,487	3,400	1,799	1,603	1,455	1,522	2,232	1,782
5	2,285	1,839	1,739	2,024	16,453	3,042	1,519	1,739	1,408	1,566	2,040	1,289
6	2,413	1,799	1,790	2,009	15,111	2,900	1,495	1,717	1,409	1,454	1,825	1,170
7	2,452	1,798	1,979	2,129	14,308	3,574	1,718	1,636	1,434	1,527	2,060	1,290
8	2,473	1,773	2,017	2,436	14,356	3,625	1,823	1,325	1,332	1,330	1,899	1,018
9	2,397	1,619	1,891	2,460	13,970	3,394	1,900	1,442	1,328	1,368	1,843	1,016
10	2,192	1,696	1,712	2,699	12,874	3,295	1,779	1,274	1,141	1,400	1,778	1,000
11	2,074	1,662	1,798	2,964	12,035	3,761	1,804	1,325	1,281	1,482	1,674	1,084
12	1,992	1,812	1,754	3,147	11,192	3,150	1,589	1,357	1,357	1,351	1,230	1,253
13	2,356	1,814	1,646	2,925	10,721	2,984	2,306	1,317	1,359	1,231	1,120	5,274
14	2,659	1,957	2,007	3,064	10,054	2,652	1,818	1,261	1,308	1,452	1,171	3,354
15	2,684	1,981	2,007	4,236	9,122	2,797	1,494	1,209	1,529	1,230	1,516	1,965
16	2,127	1,959	1,913	6,808	7,420	3,494	1,651	1,250	1,274	1,234	1,476	1,626
17	2,135	1,919	1,846	6,490	7,134	3,524	1,250	1,221	1,243	1,413	1,561	1,183
18	2,137	1,959	1,843	7,457	5,960	3,230	1,232	1,328	1,300	1,432	1,343	1,331
19	2,325	1,896	1,834	9,549	5,340	3,186	1,960	1,456	1,470	1,405	1,300	1,781
20	1,924	1,854	1,828	11,127	5,756	3,079	1,173	1,453	1,324	2,096	1,489	1,795
21	1,846	1,890	1,819	11,543	6,497	3,024	1,271	1,349	1,788	1,744	1,860	2,051
22	1,835	1,960	1,823	12,461	6,629	3,529	2,433	1,331	2,043	1,500	1,914	1,929
23	2,093	2,029	1,818	14,580	5,309	3,198	3,682	1,676	2,202	1,368	1,866	1,805
24	2,058	2,111	1,816	17,322	4,821	3,049	1,927	1,462	1,794	1,347	1,825	1,412
25	2,093	1,928	1,818	17,371	4,443	3,060	1,634	1,571	1,124	1,455	1,628	1,258
26	2,106	1,819	1,862	20,017	4,328	2,793	1,490	1,557	1,381	1,443	1,500	1,689
27	1,944	1,816	1,793	23,287	4,019	3,127	1,443	1,265	2,971	1,637	1,370	1,343
28	2,098	1,861	1,831	20,787	4,151	2,717	1,253	1,329	2,397	1,511	1,571	1,278
29	1,697	.....	1,839	21,319	4,465	3,297	1,142	1,362	2,223	2,767	1,382	1,097
30	1,760	.....	1,948	22,920	4,290	3,282	1,170	1,464	2,124	2,548	1,224	1,048
31	1,721	.....	1,976	.....	3,849	.....	1,267	1,372	.....	2,220	.....	1,437
Mean	2,111	1,843	1,848	8,709	10,114	3,238	1,817	1,428	1,580	1,604	1,733	1,606

COBBOSSEECONTEE RIVER AT RESERVOIR DAM NEAR AUGUSTA, MAINE.

This stream receives the overflow from a group of lakes lying from 5 to 15 miles westerly from Augusta, Maine, and empties into Kennebec River 8 miles below that city. It is described by Prof. Dwight Porter in the Nineteenth Annual Report, Part IV, page 79. A record of the water passing the upper dam on this stream has been furnished by Mr. Alexander H. Twombly, engineer of the Forest Paper Company, Yarmouthville, Maine. At the reservoir dam are gates by which the supply of water for the mill is regulated, and there is also a water wheel which operates a pumping station. When this wheel is in operation the regulating gates are shut down enough to deliver a constant supply of water to the mill, as shown by the tables on page 29. The great Cobbosseecontee dam furnishes a supplemental supply to this reservoir and water is occasionally drawn from it. At the point of measurement the water is shut back entirely on Sundays and holidays, as shown by the table. In the tables the reference "Gates up; all that flows" covers the period when there was no means of ascertaining the discharge, it being less than 220 second-feet and from that as low as 120 second-feet, diminishing probably at a constant rate. After November 1, 1899, the discharge, however small, can be measured.

y discharge in second-feet of Cobbosseecontee River, at the upper dam, near Augusta, Maine.

[Drainage area, 280 square miles.]

1890.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	.....	300	290	290	290	393	300
.....	.....	300	290	290	290	379	300
.....	.....	300	.....	290	290	379	300
.....	.....	.....	290	290	290	379	300
.....	.....	306	290	290	.....	368	300
.....	.....	326	290	290	290	357	300
.....	.....	356	290	.....	290	347	.....
.....	.....	374	290	290	300	347	300
.....	.....	374	290	290	300	333	300
.....	.....	340	.....	290	300	333	300
.....	.....	314	290	290	300	326	300
.....	.....	306	290	290	.....	300	300
.....	.....	156	290	290	300	300	300
.....	.....	300	290	.....	300	300	.....
.....	.....	300	290	290	300	300	300
.....	340	300	290	290	300	.....	300
.....	356	300	.....	290	300	300	300
.....	356	.....	290	290	300	379	300
.....	356	.....	290	290	.....	445	300
.....	340	290	290	290	300	431	300
.....	326	290	290	290	300	418	.....
.....	.....	290	290	290	300	405	300
.....	300	290	290	290	300	393	300
.....	300	290	84	290	337	379	300
.....	306	290	290	290	337	368	.....
.....	314	290	290	290	337	357	290
.....	314	.....	280	290	345	347	290
.....	306	290	290	.....	345	337	.....
.....	.....	290	290	290	345	337	290
.....	300	290	290	290	379	300	290
.....	.....	290	.....	.....	393	.....	290
Mean.....	324	307	290	290	313	356	298

1891.

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
290	850	839	2,169	300	300	300	290	285	260	(a)	(a)
290	780	774	2,114	300	300	300	.....	285	260	(a)	(a)
290	713	713	2,059	.....	300	300	285	280	260	(a)	(a)
.....	713	653	2,059	300	300	.....	285	280	.....	(a)	(a)
290	682	594	2,059	300	300	.....	285	280	260	(a)	(a)
290	620	567	1,940	300	300	300	285	.....	250	(a)	220
290	590	540	1,836	300	.....	300	290	280	250	(a)	220
290	.....	540	1,782	300	300	300	290	280	250	(a)	220
290	373	515	1,598	300	300	300	.....	280	250	(a)	220
290	435	540	1,567	.....	300	300	285	280	250	(a)	(a)
.....	458	743	1,495	300	300	300	285	280	.....	(a)	(a)
300	458	807	1,514	300	300	.....	285	270	250	(a)	(a)
300	458	807	1,514	300	300	290	285	.....	250	(a)	(b)
300	548	1,801	1,365	300	.....	290	285	270	250	(a)	(a)
300	529	1,753	1,223	300	300	290	285	270	250	(a)	(a)
300	590	1,573	1,270	300	300	290	.....	270	250	(a)	(a)
300	602	1,364	1,318	.....	300	290	285	270	250	(a)	(a)
300	574	1,286	1,318	300	300	290	285	270	.....	(a)	(a)
300	516	1,241	1,318	300	300	.....	285	270	220	(a)	(a)
300	516	1,204	1,318	306	300	290	285	.....	220	(a)	(b)
300	483	1,167	1,273	314	.....	290	285	270	220	(a)	(a)
300	483	1,531	1,050	316	300	290	285	270	220	(a)	(a)
503	363	2,199	1,013	300	300	290	.....	270	220	(a)	(a)
1,120	363	2,365	300	.....	300	290	285	260	220	(a)	220
1,100	393	2,365	300	300	300	290	285	260	.....	(a)	(b)
1,063	620	2,585	314	300	300	.....	285	260	220	(a)	(b)
1,063	942	2,531	306	300	300	290	285	.....	(a)	(a)	(b)
1,063	907	2,344	306	300	.....	290	285	260	(a)	(a)	220
1,063	.....	2,344	300	300	300	290	285	260	(a)	(a)	220
1,079	.....	2,344	300	300	300	290	.....	260	(a)	(a)	220
1,001	.....	2,295	.....	.....	.....	290	285	.....	(a)	.....	220
516	576	1,385	1,277	301	300	293	286	272	242	.....	.....

a Water so low only gage record kept.
b Water shut back Sundays and holidays.

Daily discharge in second-feet of Cobbosseecontee River, at the upper dam, near Augusta, Maine—Continued.

1892.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	220	270	280	280		280	280	280	280	280	280	280
2	220	270	280	280	280	280	280	280	280		280	280
3		270	280		280	280		280	280	280	280	280
4	220	280	280	280	280	280		280		280	280	
5	250	280	280	280	280		280	280	280	280	280	280
6	250	280		294	280	280	280	280	280	280		280
7	250		280	294	280	280	280		280	280	280	280
8	250	280	280	294		280	280	280	280	280	280	280
9	250	280	280	296	280	280	280	280	280		280	280
10		280	280		280	280	280	280	280	280	280	280
11	250	280	280	306	280	280	(a)	280		280	280	
12	250	280	280	294	280		(a)	280	280	280	280	280
13	250	280		280	280	280	(a)	280	280	280		280
14	250		280	280	280	280	(a)		280	280	280	280
15	270	280	280	280		280	(a)	280	280	280	280	280
16	270	280	280	280	280	280	(a)	280	280		280	280
17		280	280		280	280	(a)	280	280	280	280	280
18	270	280	280	280	280		280	280		280	280	
19	270	280	280	280	280		280	280	280	280	280	280
20	276	280		280	280	280	280	280	280	280		280
21	276		280	280	280	280	280		280	280	280	280
22	270	280	280	280	280	280	280	280	280	280	280	280
23	270	280	280	280	280	280	280	280	280		280	280
24		280	280		280	280		280	280	280		280
25	270	280	280	280	280	280	280	280		280	280	
26	270	280	280	280	280		280	280	280	280	280	280
27	270	280		280	280	280	280	280	280	280		280
28	270		280	280	280	280	280		280	280	280	280
29	270	280	280	280	280	280	280	280	280	280	280	280
30	270		280	280	280	280	280	280	280		280	280
31			280		280			280		280		280
Mean	258	279	280	283	280	280	280	280	280	280	280	280

a Water shut back.

1893.

1		280	280	535	435	300	280	280	(a)		250	230
2	280	280	280	314	458	300		280	(a)	250	250	230
3	280	280	280	300	509	300	280	280	(a)	250	250	
4	280	280	280	300	596			280	270	250	250	230
5	280	280		300	1,079	300	280	280	(a)	220		230
6	280	280	280	300	1,295	300	280		(a)	(a)	220	220
7	280	280	280	300	1,179	300	280	280	(a)	(a)	220	220
8		280	280	300	985	300	280	270	(a)	(a)	220	220
9	280	280	280		713	300		270	270	220	220	220
10	280	280	280	300	620	300	280	270		220	220	
11	280	280	280	314	590		280	270	270	220	220	220
12	280			481	562	280	280	270	270	220		230
13	280	280	280	682	562	280	280		270	(a)	220	230
14	280	280	509	650	887	280	280	270	270	(a)	220	230
15		280	620	650	1,262	280	280	270	(a)	(a)	220	220
16	280	280	620	1,040	1,354	280		270	(a)	220	220	220
17	280	280	535	1,079	1,552	280	280	270	(a)	220	220	
18	280	280	509	1,001	2,680		280	270	270	220	220	220
19	280		458	962	2,481	280	280	270	270	(a)		230
20	280	280	435	925	2,002	280	280		270	(a)	220	220
21	280	280	393	887	1,900	280	280	270	270	(a)	220	230
22		280	393	962	1,752	280	280	270	(a)	(a)	220	230
23	280	280	356	962	1,660	280		270	(a)	(a)	220	230
24	280	280	356	925	1,428	280	280	270	(a)	(a)	220	
25	280	280	356	780	1,052		280	270	250	250	220	
26	280		458	713	562	280	280	270	250	250		230
27	280	280	590	620	326	280	280		250	250	220	230
28	280	280	620	650	326	280	280	270	250	250	220	230
29			562	620	326	280	280	270	250		220	230
30	280		780	393	326	280		270	250	250		230
31	280		620		307		280	270		250		
Mean	280	280	422	629	1,025	287	280	272	263	236	225	230

a Water shut back.

discharge in second-feet of Cobbosseecontee River, at the upper dam, near Augusta, Maine—Continued.

1894.

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
220	220	220	.....	300	325	.....	220	220	220	220	220
220	220	220	314	300	299	220	220	.....	220	220	.....
220	220	220	314	300	274	220	220	.....	220	220	220
220	.....	.....	306	220	226	.....	220	220	220	.....	220
220	220	220	306	220	226	220	.....	220	220	220	220
220	220	220	306	.....	226	220	220	220	220	220	220
.....	220	220	306	220	226	220	220	220	220	220	220
220	220	220	26	220	226	.....	220	220	220	220	220
220	220	220	326	220	226	220	220	.....	220	220	.....
220	220	220	314	220	220	220	220	220	220	220	220
220	.....	.....	314	220	226	220	220	220	220	.....	220
220	220	276	314	220	314	220	.....	220	220	220	220
220	220	483	314	.....	300	220	220	220	220	220	220
.....	220	483	314	220	220	220	220	220	.....	220	220
220	220	436	.....	220	220	.....	220	220	220	220	220
220	220	436	430	220	220	220	220	.....	220	220	.....
220	220	410	430	220	.....	220	220	220	220	220	220
220	.....	405	430	220	220	220	220	220	220	.....	220
220	220	405	314	220	220	220	.....	220	220	220	220
220	220	630	314	.....	220	220	220	220	220	220	220
.....	220	909	314	220	220	220	220	220	.....	220	220
220	220	867	26	220	220	.....	220	220	220	220	220
220	220	692	326	220	220	220	220	.....	220	220	.....
220	220	308	314	220	.....	220	220	220	220	220	220
220	.....	14	314	220	220	220	220	220	220	.....	.....
220	220	314	306	336	220	220	.....	220	220	220	220
220	220	314	300	523	220	220	220	220	220	220	220
.....	220	314	300	499	220	220	220	220	.....	220	220
220	.....	300	.....	370	220	.....	220	220	220	.....	220
220	.....	300	300	523	220	220	220	.....	220	220	.....
220	.....	300	.....	862	.....	220	220	.....	220	.....	220
220	220	364	306	333	350	220	220	272	251	220	220

1895.

250	250	.....	250	385	280	280	280	.....	220	(a)	.....
250	250	.....	250	318	.....	280	280	270	220	(a)	220
250	.....	.....	250	300	280	280	280	270	220	.....	220
250	220	220	250	290	280	.....	.....	270	(a)	(a)	220
250	220	220	250	.....	280	280	280	270	(a)	(a)	220
.....	220	220	250	280	280	280	280	270	.....	(a)	220
250	220	220	14	280	280	.....	280	270	220	(a)	220
250	220	.....	343	280	280	280	280	.....	(a)	(a)	.....
250	220	220	733	280	.....	280	280	270	(a)	(a)	220
250	.....	.....	2,619	280	280	280	280	250	(a)	.....	220
250	220	220	1,301	280	280	280	.....	250	(a)	(a)	220
250	220	220	1,384	.....	280	280	270	250	(a)	(a)	220
.....	220	220	300	280	280	280	270	250	.....	(a)	220
250	220	220	74	280	280	.....	270	250	(a)	(a)	220
250	220	220	2,603	280	280	280	270	.....	(a)	(a)	.....
250	220	220	2,461	280	.....	280	270	250	(a)	(a)	220
250	.....	.....	1,698	280	280	280	270	250	(a)	.....	220
250	220	220	1,609	280	280	280	.....	250	(a)	220	220
250	220	220	1,400	.....	280	280	270	250	(a)	220	220
.....	220	220	1,271	280	280	280	270	(a)	.....	220	220
250	220	220	480	.....	280	.....	270	(a)	(a)	220	220
250	220	220	664	280	280	280	270	.....	(a)	220	.....
250	220	220	358	280	.....	280	270	220	(a)	220	220
250	.....	.....	385	280	280	280	270	220	(a)	.....	220
250	220	220	385	280	280	280	.....	220	(a)	220	.....
250	220	220	385	.....	280	280	270	220	(a)	220	250
.....	220	220	385	280	280	280	270	220	.....	220	250
250	.....	220	409	280	280	.....	270	220	(a)	.....	250
250	.....	220	409	280	280	280	270	.....	(a)	220	14
250	.....	220	409	280	.....	280	270	220	(a)	220	264
250	.....	.....	.....	280	.....	280	270	.....	(a)	.....	343
250	223	220	785	287	280	280	273	247	220	220	223

a Gates up; natural flow.

Daily discharge in second-feet of Cobbosseecontee River, at the upper dam, near Augusta, Maine—Continued.

1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	270	.....	901	300	280	280	280	250	250	.....	250
2	451	.....	1,959	903	300	280	280	.....	250	250	220	250
3	276	270	2,498	901	.....	280	280	280	250	250	220	250
4	264	270	1,959	856	300	280	.....	280	250	.....	220	250
5	.....	270	1,637	856	300	280	.....	270	250	250	220	250
6	270	270	1,219	856	300	280	280	270	.....	250	220	.....
7	270	270	1,219	856	280	.....	280	270	250	250	220	250
8	270	270	1,226	856	280	280	280	270	250	250	.....	250
9	270	.....	1,368	769	280	280	280	.....	250	250	220	250
10	270	270	1,368	727	.....	280	280	270	250	250	220	250
11	270	270	946	727	280	280	280	270	250	.....	220	250
12	.....	270	1,038	727	280	280	.....	270	250	250	220	250
13	270	270	1,086	727	280	280	280	270	.....	250	220	.....
14	270	270	1,038	812	280	.....	280	270	250	220	220	250
15	270	270	901	812	280	280	280	270	270	220	.....	250
16	270	.....	769	901	280	280	280	.....	270	220	220	250
17	270	270	727	946	.....	280	280	270	270	220	220	250
18	270	270	685	1,188	280	280	280	270	250	.....	250	250
19	.....	270	856	1,236	280	280	.....	270	250	220	250	250
20	270	270	993	1,039	280	280	280	270	.....	220	250	.....
21	270	270	1,581	901	280	.....	280	270	250	220	250	250
22	270	270	1,429	992	280	280	280	270	250	220	.....	250
23	270	.....	1,275	1,039	280	280	280	.....	250	220	250	250
24	270	280	1,056	901	.....	280	280	270	250	220	250	250
25	270	280	728	769	280	280	280	270	250	.....	250	.....
26	.....	280	686	644	280	280	.....	270	250	220	.....	250
27	270	280	812	526	280	280	280	270	.....	220	250	.....
28	270	280	769	300	280	.....	280	270	250	220	250	250
29	270	280	727	300	280	280	280	270	250	220	.....	250
30	270	.....	644	300	.....	280	280	.....	250	220	250	250
31	270	.....	727	.....	.....	.....	280	250	.....	220	.....	250
Mean	277	272	1,138	812	284	280	280	270	252	232	233	250

1897.

1	250	250	250	497	280	600	280	.....	280	280	270	270
2	250	250	250	517	.....	477	280	280	280	280	270	270
3	.....	250	250	574	368	573	280	280	280	.....	270	270
4	250	250	250	350	624	523	.....	280	280	280	270	270
5	250	250	250	620	630	477	100	280	.....	280	270	.....
6	250	250	250	650	320	262	280	280	280	280	270	270
7	250	.....	.....	650	320	336	280	280	280	280	.....	270
8	250	250	250	650	320	336	280	.....	280	280	270	270
9	250	250	250	620	74	320	280	280	280	280	270	270
10	.....	250	250	620	373	320	280	280	280	.....	270	270
11	250	250	250	650	393	512	.....	280	280	280	270	270
12	250	250	250	590	393	559	280	280	.....	280	270	.....
13	250	250	250	421	393	679	280	280	280	280	270	270
14	250	.....	.....	310	.....	679	280	280	280	270	.....	270
15	250	250	250	356	489	436	280	.....	280	(a)	270	270
16	250	250	250	522	244	354	280	280	280	(a)	270	270
17	.....	250	250	497	509	320	280	280	280	(a)	270	270
18	250	250	250	497	833	294	.....	280	280	(a)	270	280
19	250	550	250	473	769	286	280	280	.....	(a)	270	.....
20	250	250	250	453	739	6	280	280	280	(a)	270	280
21	250	.....	.....	320	709	286	280	280	280	(a)	.....	280
22	250	250	250	294	391	436	280	.....	280	(a)	270	280
23	250	250	250	286	6	654	280	280	280	(a)	270	280
24	.....	250	250	280	280	365	280	280	280	.....	270	280
25	250	250	250	14	280	294	.....	280	280	270	270	21
26	250	250	250	286	280	286	280	280	.....	270	270	.....
27	250	250	250	280	280	.....	280	280	280	270	270	280
28	250	.....	.....	286	320	280	280	280	280	270	.....	280
29	250	.....	250	286	19	280	280	.....	280	270	270	280
30	250	.....	250	280	914	280	280	280	280	270	270	280
31	.....	.....	306	.....	772	.....	280	280	.....	.....	.....	280
Mean	250	250	252	438	425	397	273	280	280	276	270	265

a Gates up; all that flows.

Daily discharge in second-feet of Cobbosseecontee River, at the upped dam, near Augusta, Maine—Continued.

1898.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	280	280	413	.....	478	280	280	280	250	250	250	250
2	.....	280	394	.....	478	280	280	280	250	.....	250	250
3	280	280	443	1,016	478	280	.....	280	250	250	250	250
4	280	280	408	1,098	455	280	19	280	.....	250	250	.....
5	280	280	408	1,098	455	.....	280	280	250	250	250	270
6	280	.....	387	1,098	433	280	280	280	250	250	.....	270
7	280	280	466	1,098	433	280	280	.....	250	250	250	270
8	280	280	529	1,098	273	280	280	280	250	250	250	270
9	.....	280	503	1,098	333	280	280	280	250	.....	250	270
10	280	280	474	1,098	333	280	.....	280	250	250	250	270
11	280	280	456	584	314	280	280	280	.....	250	250	.....
12	280	280	559	531	300	.....	280	280	250	250	250	270
13	280	.....	597	396	300	280	280	280	250	250	.....	270
14	280	280	821	396	300	280	280	.....	250	250	250	270
15	280	280	1,148	334	.....	280	280	280	250	250	250	270
16	.....	300	1,111	376	300	280	280	270	250	.....	250	270
17	280	300	1,039	413	300	280	.....	270	250	220	250	270
18	280	300	969	433	300	280	280	270	.....	220	250	.....
19	280	300	969	433	300	.....	280	270	250	220	250	270
20	280	300	1,016	433	300	280	280	270	250	220	.....	270
21	280	328	1,222	433	300	280	280	.....	250	220	250	270
22	280	328	1,184	433	.....	280	280	270	250	220	250	270
23	.....	333	1,147	433	300	280	280	270	250	.....	250	270
24	280	445	1,222	433	300	280	.....	270	250	220	.....	270
25	280	504	1,261	555	280	280	280	270	.....	220	250	.....
26	280	477	1,222	732	280	.....	280	270	250	220	250	270
27	280	435	1,125	682	280	280	280	270	250	220	.....	270
28	280	433	1,147	478	280	280	280	.....	250	250	250	270
29	280	.....	1,184	478	.....	280	280	270	250	250	250	270
30	.....	.....	1,147	620	280	280	280	270	250	.....	250	270
31	280	.....	1,147	.....	280	.....	.....	270	.....	250	.....	270
Mean	280	324	843	633	337	280	270	275	252	238	250	268

1899.

1	.....	270	270	300	300	280	280	280	270	(a)	160	160
2	270	270	270	306	300	280	.....	280	270	(a)	180	160
3	270	270	270	306	300	280	280	280	.....	(a)	180	.....
4	270	270	270	396	300	.....	19	280	270	(a)	170	180
5	270	.....	.....	359	300	280	280	280	250	(a)	.....	180
6	270	270	270	373	300	280	280	.....	250	(a)	180	180
7	270	270	250	395	.....	280	280	280	250	(a)	175	170
8	.....	270	270	502	300	280	280	280	250	(a)	170	150
9	270	270	270	842	300	280	.....	280	(a)	(a)	170	135
10	270	270	270	1,198	300	280	280	280	.....	(a)	150	.....
11	270	270	270	1,262	300	.....	280	280	250	(a)	150	120
12	270	.....	.....	984	300	280	280	280	250	(a)	.....	120
13	270	270	270	772	300	280	280	.....	250	(a)	150	120
14	270	270	270	809	.....	280	280	280	(a)	(a)	150	120
15	.....	270	270	809	290	280	280	280	(a)	(a)	140	120
16	270	270	270	787	290	280	.....	270	(a)	(a)	130	140
17	270	270	270	947	290	280	280	270	.....	(a)	130	.....
18	270	270	270	1,243	290	.....	280	270	250	(a)	130	140
19	270	.....	.....	1,387	290	280	280	270	(a)	(a)	.....	135
20	270	270	270	1,427	290	280	280	.....	(a)	(a)	160	135
21	270	270	270	1,403	.....	280	280	270	(a)	(a)	170	135
22	.....	270	270	1,331	280	280	280	270	(a)	(a)	180	135
23	270	270	270	1,145	20	280	.....	270	(a)	(a)	180	135
24	270	270	270	1,130	280	280	280	270	.....	(a)	180	.....
25	270	270	270	870	280	.....	280	270	220	(a)	180	.....
26	270	.....	.....	669	280	280	280	270	(a)	(a)	.....	150
27	270	270	270	635	280	280	280	.....	(a)	(a)	170	150
28	270	270	270	470	.....	280	280	270	(a)	(a)	165	140
29	.....	.....	280	324	280	280	280	270	(a)	(a)	150	140
30	270	.....	280	.....	280	280	.....	270	(a)	(a)	.....	140
31	270	.....	280	.....	280	.....	280	270	.....	.....	.....	.....
Mean	270	270	270	808	281	280	270	275	252	.....	162	144

a Gates up; all that flows.

MERRIMAC RIVER AT MANCHESTER, NEW HAMPSHIRE.

This stream receives the drainage from a considerable portion of the White Mountain area in New Hampshire. Its flow is regulated by a number of large lakes near the headwaters, the outlets of many of which are controlled by dams. The fall of the stream is considerable and developments of water power have taken place to an extent probably greater than in any other part of the United States. At Manchester records of the height are taken several times a day, generally on the even hours. Mr. H. W. Allen, of the Amoskeag Manufacturing Company, states that the ordinary flow of Merrimac River at that place for eight months of the year is 2,100 second-feet. With this quantity all the water wheels can be run. The minimum low-season flow for this year he would call 1,084 second-feet. The length of the main dam is 400 feet, and the wing 231 feet. The dam is 177.99 feet above mean tide water at the mouth of the river. Three-foot flashboards can be used in all months except March, April, and May, and then only 2-foot boards. The pondage extends to Hooksett, 8 miles, and covers 443.65 acres. The highest water on the dam of which there is record was on March 2, 1896, when there was 10.95 feet in height, flowing over. The drainage area above Manchester is 2,839 square miles.

MERRIMAC RIVER AT LAWRENCE, MASSACHUSETTS.

The longest and most careful series of computations of river flow are probably those kept at Lawrence, Massachusetts, having been begun by Mr. J. B. Francis for the Essex Company, and maintained by Mr. Hiram Mills and Mr. R. A. Hale. These extend over fifty years, but have never been published in full. The maximum, minimum, and mean discharge by months, from 1890 to 1897, has been printed in the Nineteenth Annual Report, Part IV, pages 113 to 115, and similar figures for 1898 have been given in the Twentieth Annual Report, Part IV, page 73, accompanied by a diagram showing the fluctuations from 1891 to 1898, inclusive.

Daily discharge of Merrimac River, at Lawrence, Massachusetts, in cubic feet per second.

1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2,807	3,776	3,963	14,398	9,957	9,153	5,662	9,229	3,074	2,647	2,374	3,130
2	1,943	2,931	3,686	14,646	10,049	8,000	7,087	8,574	3,307	1,872	2,782	4,408
3	2,180	2,775	3,689	15,368	10,908	7,394	6,407	7,539	3,840	440	4,666	4,206
4	4,009	2,720	4,790	15,908	11,598	7,673	5,459	6,576	2,438	3,449	9,216	3,391
5	4,000	2,730	5,943	16,067	12,514	9,128	5,000	6,352	2,347	2,737	7,604	3,216
6	4,816	1,902	6,944	18,116	11,949	10,517	5,454	6,577	2,864	2,544	5,474	6,430
7	6,707	2,380	8,062	21,268	10,737	10,469	4,816	6,374	4,460	2,570	3,897	8,902
8	7,325	5,779	10,590	22,974	9,443	9,468	4,725	5,057	2,854	2,896	4,879	7,825
9	5,285	7,946	9,385	22,617	7,859	8,307	4,369	5,164	2,625	1,534	3,741	6,398
10	4,082	9,427	9,125	24,513	7,613	15,264	3,816	4,551	2,790	340	4,109	5,971
11	5,076	9,094	10,100	24,483	6,562	40,572	3,393	4,575	2,022	2,542	5,680	5,172
12	3,990	7,589	12,300	21,510	7,714	35,923	4,841	5,043	1,424	2,498	6,950	5,334
13	3,313	6,214	13,680	17,958	8,849	26,829	3,370	5,096	3,736	2,562	8,033	8,124
14	3,364	4,821	13,350	16,235	14,051	21,473	16,921	4,280	2,934	2,669	7,923	9,850
15	2,989	5,429	11,243	15,573	24,681	19,643	32,498	3,729	2,644	2,428	7,441	15,100
16	2,026	4,759	10,365	18,789	19,305	17,539	41,499	4,983	2,684	2,454	6,259	32,300
17	1,834	4,539	8,904	23,407	14,171	14,396	26,568	4,073	2,658	1,892	6,231	36,800
18	4,030	4,343	8,472	23,271	11,448	12,675	16,908	4,139	1,900	3,805	6,909	28,304
19	3,231	4,392	8,092	20,626	9,481	11,416	13,672	4,721	1,044	2,770	7,378	20,203
20	3,104	3,388	9,216	18,710	8,301	9,217	11,173	4,522	3,717	2,716	6,019	14,157
21	2,965	3,467	11,156	17,085	7,607	10,348	9,853	2,860	3,020	2,502	4,801	12,113
22	3,025	4,847	13,373	14,605	6,657	10,297	9,137	3,169	2,804	2,390	5,331	10,563
23	2,357	4,306	13,627	13,058	5,732	9,375	8,650	5,118	2,768	1,525	4,960	10,878
24	2,322	3,812	16,735	12,203	6,313	7,931	9,098	3,520	2,446	398	4,851	9,169
25	4,049	4,241	18,717	13,761	5,676	7,117	10,241	4,480	1,886	3,096	3,022	9,170
26	2,997	4,036	17,871	15,884	6,716	6,877	12,121	5,467	1,370	2,566	5,424	7,065
27	2,783	3,427	15,549	16,933	8,226	6,478	11,661	5,285	4,019	2,341	4,390	7,633
28	2,771	2,869	12,944	15,214	9,060	6,376	10,466	3,996	3,087	2,506	7,816	6,116
29	2,699	.....	11,758	12,341	10,277	5,569	9,070	3,640	2,874	2,268	9,714	5,831
30	1,994	.....	41,498	10,947	10,626	5,246	9,782	5,007	2,671	1,648	6,924	5,653
31	1,721	.....	12,777	.....	9,616	.....	10,448	3,340	.....	176	.....	5,410
Mean	3,409	4,571	10,571	17,611	10,117	12,708	10,799	5,072	2,759	2,207	5,827	10,376

1898.

1	4,751	5,000	10,050	19,795	16,279	9,964	3,853	3,575	3,337	2,455	8,384	9,778
2	4,246	5,550	9,500	17,566	14,774	8,697	2,826	2,833	3,224	2,077	7,759	9,856
3	8,200	5,100	9,240	15,026	13,387	7,771	2,623	2,617	2,580	3,951	7,157	9,141
4	6,520	5,325	8,840	13,254	12,708	7,131	2,741	2,575	2,163	3,034	6,525	8,271
5	5,790	5,250	8,350	12,195	12,535	7,124	4,516	2,624	2,714	3,055	5,871	11,050
6	5,650	5,400	6,850	11,459	12,647	7,865	3,225	1,893	3,847	3,761	5,204	16,808
7	5,380	6,150	8,800	11,004	12,630	7,163	2,721	1,969	3,146	5,827	6,114	17,398
8	5,500	6,070	8,350	10,740	11,583	6,774	2,768	4,112	3,134	5,759	5,477	15,190
9	5,260	5,600	8,940	10,128	11,144	6,585	2,015	3,056	3,043	5,393	5,319	12,245
10	7,580	6,200	10,080	9,529	10,035	6,276	1,135	2,949	2,307	6,080	5,617	9,637
11	6,520	6,150	11,380	9,742	8,452	5,619	3,805	3,563	1,705	4,897	9,353	8,591
12	5,910	7,330	14,080	10,058	8,109	5,267	2,918	4,020	3,750	4,667	15,304	8,855
13	6,040	7,320	17,600	10,386	8,552	5,706	2,707	3,221	2,910	4,484	14,746	6,699
14	7,180	10,460	28,800	11,072	12,530	5,598	2,620	3,032	2,630	4,043	12,781	6,330
15	8,170	10,120	36,000	11,507	11,834	6,832	2,533	4,744	2,556	3,367	10,971	6,532
16	7,540	9,980	35,100	13,588	10,458	8,511	1,859	3,645	2,483	4,361	9,784	6,715
17	9,700	8,400	30,000	17,111	9,959	7,213	1,018	3,412	1,720	6,023	8,962	6,279
18	7,770	7,750	26,100	17,021	9,505	5,205	3,551	3,115	372	5,325	8,622	5,908
19	6,790	8,460	25,200	15,048	8,858	4,506	2,517	3,337	2,800	4,982	9,810	6,841
20	6,040	6,850	25,000	14,330	8,307	5,923	2,568	3,359	2,460	5,055	15,303	6,378
21	7,300	9,080	27,600	13,717	7,472	7,026	2,581	5,459	2,335	6,075	19,785	6,144
22	9,340	9,270	30,200	13,493	7,302	7,908	2,920	6,261	2,264	7,421	17,553	6,084
23	9,140	9,930	25,800	12,121	7,404	6,694	2,360	5,469	2,399	10,178	14,351	6,876
24	11,480	10,430	22,300	13,666	6,160	6,590	2,327	4,439	1,760	11,583	11,625	9,007
25	11,100	10,790	21,800	25,342	7,316	5,790	3,919	4,892	1,867	9,962	11,699	10,290
26	10,500	10,740	20,000	30,362	10,501	5,142	2,851	5,403	6,075	8,307	11,113	9,534
27	9,450	8,900	17,000	27,394	14,041	5,458	2,724	4,913	5,144	8,909	9,627	8,892
28	8,960	10,700	17,900	22,139	15,785	5,110	2,709	4,527	4,525	13,699	6,872	8,425
29	8,040	.....	18,000	19,424	15,081	4,567	2,713	5,306	4,198	14,473	6,253	6,572
30	6,620	.....	18,400	18,612	13,713	3,908	1,753	3,806	3,830	10,534	8,677	6,024
31	6,750	.....	19,700	.....	11,811	.....	1,081	3,657	.....	9,565	.....	5,792
Mean	7,394	7,797	18,612	15,229	10,996	6,464	2,660	3,799	2,910	6,429	9,887	8,779

Daily discharge of Merrimac River, at Lawrence, Massachusetts, in cubic feet per second—Continued.

1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5,661	5,145	7,360	16,700	22,870	4,277	2,019	2,925	2,188	497	2,829	2,677
2	6,511	4,919	7,810	14,840	23,647	3,907	387	2,370	1,666	3,156	3,542	1,941
3	6,004	4,841	7,379	15,160	23,410	3,231	2,131	2,423	509	2,519	3,632	908
4	6,643	3,659	6,837	14,590	23,158	2,701	1,500	2,659	1,987	2,337	3,692	3,219
5	7,863	3,531	6,992	14,680	18,876	4,292	3,691	1,806	3,359	2,193	2,889	2,834
6	10,816	5,458	10,630	15,190	15,125	3,601	2,770	749	3,120	2,282	4,645	2,846
7	11,519	4,240	13,059	16,400	12,428	3,065	2,927	3,604	2,743	1,739	3,617	2,768
8	10,373	4,501	12,859	18,400	11,694	2,944	2,044	2,784	2,378	288	3,205	2,847
9	10,024	4,087	11,968	25,000	10,618	3,214	570	2,186	1,745	2,244	3,034	1,868
10	8,747	4,308	10,628	29,200	9,652	2,450	3,984	2,248	426	2,156	3,024	665
11	7,572	3,344	9,194	29,400	8,827	1,981	3,346	2,635	2,664	2,204	2,473	3,192
12	6,831	3,075	9,161	28,200	8,564	3,806	2,996	1,886	2,307	2,107	863	2,715
13	6,358	4,731	13,795	26,000	7,706	3,076	3,176	372	2,247	2,007	3,729	2,236
14	5,611	3,576	18,900	25,600	7,131	2,731	2,948	3,123	2,250	959	3,069	3,369
15	6,126	3,740	18,600	30,000	7,440	2,457	2,055	2,768	2,217	61	2,879	5,051
16	8,214	3,845	17,500	34,400	6,376	2,857	685	2,196	1,441	2,020	2,770	3,772
17	9,681	3,933	15,200	38,200	6,422	2,317	3,678	2,125	69	1,962	2,846	2,478
18	11,329	3,617	15,000	35,527	5,932	2,481	2,810	2,468	1,960	2,061	1,999	3,969
19	10,799	4,092	12,330	33,498	5,650	4,430	2,851	1,857	1,762	2,354	548	2,814
20	9,211	5,747	12,920	34,623	5,213	2,866	2,476	355	1,804	2,460	3,462	2,892
21	7,823	5,749	12,040	34,310	5,468	2,894	2,488	2,098	2,168	1,373	3,076	3,387
22	6,839	6,083	12,210	30,583	6,800	3,101	1,706	2,257	2,496	50	2,914	3,868
23	7,317	6,550	11,500	27,846	5,897	2,865	525	2,187	1,816	2,126	2,805	2,851
24	6,713	7,098	11,340	29,483	5,654	2,096	3,808	2,123	293	1,667	2,603	2,283
25	7,306	6,885	11,260	31,656	4,909	1,134	2,906	2,136	2,560	1,820	2,312	2,798
26	8,291	6,309	9,400	31,367	4,823	3,582	2,893	1,674	2,633	1,978	1,291	4,334
27	8,192	6,988	11,130	31,157	4,022	2,883	2,599	78	2,453	2,333	3,380	3,667
28	6,870	6,637	10,360	3[illegible],816	3,543	2,841	2,949	2,067	2,191	1,399	2,909	2,954
29	5,906	.....	11,240	26,805	5,255	2,506	2,241	2,153	2,452	123	2,789	2,916
30	6,808	.....	14,600	23,507	3,862	2,846	1,984	2,222	1,906	2,513	947	1,838
31	5,504	.....	17,200	.....	4,383	.....	3,781	2,132	.....	2,460	.....	593
Mean	7,857	4,882	11,948	26,438	9,528	2,980	2,481	2,086	1,994	1,789	2,792	2,797

NASHUA RIVER AT CLINTON, MASSACHUSETTS.

This river receives the drainage of a portion of central Massachusetts, and flows in a general northerly course into New Hampshire, emptying into Merrimac River. The principal part of the drainage basin is shown on the Worcester, Marlboro, Framingham, and Groton topographic atlas sheets. On its headwaters, near the town of Clinton, the metropolitan water board has under construction what is known as Wachusett reservoir, for the supply of Boston and neighboring towns. Measurements of the flow of Nashua River have been made at Clinton since July, 1896, but these have not been published, as there are unsettled claims for the diversion of the water. The rainfall on the watershed during 1897 was measured at four localities, and ranged from about 50 to 53 inches. The area and capacity of Wachusett reservoir are given for each 5 feet in elevation in the Report of the State Board of Health of Massachusetts for 1895 on "Metropolitan water supply," pages 127 and 128. The outline of the reservoir is also shown on an accompanying plan.

SUDBURY RIVER.

This small stream of eastern Massachusetts, receives water from n area west of Framingham. It flows in a northerly course through neadows and swamps, and joins Assabet River to form Concord River, which in turn continues northerly, entering Merrimac River nmediately below the city of Lowell. Storage reservoirs have been onstructed by the city of Boston, controlling the greater part of the ow from this basin. The available water has been systematically neasured by Mr. Desmond FitzGerald, the record beginning in 1875. 'he run-off in cubic feet per second, by months, from 1875 to 1898, is iven in the Twentieth Annual Report, Part IV, page 75.[1] The fol-owing is a continuation of this table. It should be noted that during August the yield of Sudbury River is a minus quantity.

Run-off of Sudbury River and Lake Cochituate watersheds in second-feet per square mile.

Month.	Sudbury River.		Lake Cochituate.	
	1899.	Averages, 1875-1899.	1899.	Averages, 1863-1899.
January	3.54	1.94	2.99	1.78
February	2.14	2.90	2.22	2.53
March	6.51	4.49	5.51	3.32
April	3.90	3.12	2.55	2.60
May	.79	1.68	.60	1.51
June	.10	.74	.10	.70
July	.08	.31	.08	.47
August	−.05	.48	.08	.67
September	.15	.38	.45	.65
October	.18	.83	.54	.92
November	.47	1.47	.45	1.33
December	.34	1.61	.35	1.46
The year	1.51	1.66	1.32	1.49

LAKE COCHITUATE.

This lake drains into Sudbury River below the point of diversion for the water supply of the city of Boston, and has been considered as a separate watershed, with an area of 18.87 square miles, of which 7.6 per cent is water surface. Dudley Pond, which lies just north of the lake, is connected with it, and water is occasionally drawn into the lake. The watershed of this pond is not included in the 18.87 square miles; thus a corresponding deduction must be made in computing the yield. This correction has been made in the accompanying table. Figures of catchment on this area since 1863 are available, these not being considered quite as accurate as those for Sudbury River. The results in inches of depth of run-off from the watershed are given in the following table. The average yield per square mile of this watershed for thirty-seven years, 1863 to 1899,

[1] For low water flow, see Engineering Record, September 16, 1899.

inclusive, is given in the second table, which shows by months the second-feet per square mile, the corresponding depth of run-off in inches, the depth of rainfall, and the percentage collected:

Yield of Lake Cochituate watershed in inches in depth.

[Drainage area, 18.87 square miles.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1863	1.91	3.12	3.71	4.41	1.44	0.66	2.94	1.54	0.99	1.31	2.64	2.19	26.87
1864	2.41	1.56	4.09	2.65	1.61	.49	.41	.67	.49	1.42	1.24	1.17	18.22
1865	2.06	1.76	4.66	2.71	4.75	.33	.46	.48	.44	.69	1.02	1.13	20.49
1866	.74	2.84	1.78	1.62	1.29	1.09	1.26	.64	1.32	.94	.97	1.55	16.63
1867	1.10	5.24	3.47	2.86	2.18	.66	.56	2.10	.31	1.05	1.11	1.12	21.77
1868	1.23	1.12	3.85	3.49	6.18	1.60	.46	1.15	1.82	.95	1.99	1.17	24.99
1869	1.82	1.87	3.33	2.48	2.17	1.05	.75	.59	1.11	2.33	1.30	3.16	21.96
1870	4.73	3.95	3.37	6.86	1.66	.97	.53	.40	.64	.96	.80	.78	25.66
1871	1.03	2.28	2.53	1.58	2.00	.87	.43	.70	.28	.61	1.23	1.18	14.74
1872	1.10	.89	1.35	2.96	1.10	1.48	.14	1.32	1.70	1.70	1.99	1.20	16.94
1873	3.10	1.58	3.90	6.08	2.66	.45	.61	1.43	.79	2.02	1.86	2.69	27.17
1874	3.12	2.20	1.84	3.18	2.79	1.96	.95	.92	.53	.52	.57	.51	19.09
1875	.15	2.93	2.66	3.17	1.39	1.50	.25	.61	.58	1.21	1.98	1.22	17.65
1876	1.08	1.77	5.20	4.21	1.43	.51	.85	.28	.58	.36	1.85	1.00	19.12
1877	1.20	1.37	6.81	3.24	2.04	.92	.64	.66	.40	1.12	2.69	1.97	23.06
1878	3.25	3.97	5.40	2.86	1.86	.76	.47	.84	.39	.73	2.07	4.04	26.34
1879	1.29	2.32	3.30	4.48	1.40	.77	.33	.95	.61	.60	.72	1.04	17.81
1880	1.47	2.24	1.79	1.57	.44	.06	.33	.23	.24	.28	.66	.59	9.90
1881	1.19	2.23	5.66	1.79	1.26	1.31	.16	.09	.23	.18	.84	1.40	16.34
1882	1.84	3.00	3.67	.93	1.55	.62	.06	.07	.97	.84	.58	.92	15.05
1883	.84	1.59	2.04	1.66	1.26	.07	.02	.07	.44	.44	.40	.94	9.76
1884	1.84	2.86	4.67	4.00	1.39	.67	.26	.61	.13	.34	.62	1.82	19.21
1885	1.90	2.00	2.21	2.36	1.61	.43	.00	.23	.25	.79	2.05	1.64	15.57
1886	2.28	7.93	3.51	2.52	1.09	.18	.25	.14	.30	.42	1.20	2.10	21.92
1887	4.06	4.34	4.70	3.36	1.35	.82	.72	1.33	.64	.49	.70	.96	23.47
1888	1.13	2.77	4.76	3.45	2.37	.53	.47	.94	2.31	2.57	4.21	5.46	30.97
1889	4.50	1.85	2.08	2.17	1.20	1.18	1.63	3.43	1.79	1.91	2.95	3.26	27.95
1890	1.92	2.04	5.87	2.23	1.85	1.41	.33	.46	1.40	3.40	1.49	2.11	24.51
1891	6.26	6.62	8.03	4.31	.88	.77	.50	.72	.76	.79	.83	1.26	31.73
1892	8.03	1.54	3.02	.90	2.03	.49	.33	.56	.60	.57	1.09	.84	15.02
1893	.64	2.55	4.12	2.42	1.83	.75	.38	.77	.42	1.08	0.83	1.48	17.27
1894	1.21	1.67	2.55	2.15	.91	.45	.38	.41	.46	.66	.92	1.14	12.91
1895	1.58	.75	3.50	3.35	.97	.40	.55	.50	.69	1.97	3.51	2.40	20.17
1896	1.72	3.69	5.52	2.01	.62	.71	.38	.47	1.03	1.28	1.40	1.31	20.14
1897	1.64	1.65	3.22	1.85	1.39	1.19	.75	.63	.46	.43	1.68	2.16	17.05
1898	2.27	4.06	3.11	2.69	1.86	.78	.37	1.30	.31	1.61	2.31	2.74	23.41
1899	3.45	2.31	6.35	2.84	.69	.11	.03	.09	.50	.63	.50	.41	17.91
Mean	2.056	2.662	3.828	2.903	1.738	.784	.539	.767	.725	1.059	1.482	1.677	20.229

Average yield per square mile of Lake Cochituate watershed, 1863 to 1899, inclusive

[Drainage area, 18.87 square miles.]

Month.	Second-feet per square mile.	Run-off in inches.	Rainfall in inches.	Per cent.
January	1.78	2.06	4.00	51.4
February	2.53	2.66	3.93	67.8
March	3.32	3.83	4.34	88.2
April	2.60	2.90	3.51	82.7
May	1.51	1.74	3.78	46.0
June	.70	.78	2.96	26.5
July	.47	.54	4.21	13.0
August	.67	.77	4.49	17.1
September	.65	.72	3.44	21.1
October	.92	1.06	4.56	23.2
November	1.33	1.48	4.38	33.9
December	1.46	1.68	3.40	49.3
The year	1.49	20.28	47.00	43.0

MYSTIC LAKE.

The area tributary to Mystic Lake lies about 10 miles north of oston and contains 26.9 square miles, including about 3 per cent of ater surface. It has been the source of water supply for the city of harlestown since 1864. Upon the annexation of that city to Boston ie source of supply passed into the control of the Boston waterworks, iis being in 1876. The records of run-off extend from 1878 to 1897, iclusive. On January 1, 1898, the lake was abandoned as a source f water supply and records after that date are not available. The able given below is from the third annual report of the water comiissioners of the city of Boston. These records are somewhat less ccurate than those for Lake Cochituate, as they involve not only torage in Mystic Lake, which has been determined with a fair degree of accuracy, but also the quantity of water pumped by five engines, he slip of which was somewhat uncertain, and the flow through a fishway. There are also a number of other points on the watershed whose storage should have been considered.

The yield from this watershed in depth in inches for the years 1878 to 1897, inclusive, is given in the table on page 40. The average yield per square mile is given in the following table, these figures being obtained from the engineering department of the Metropolitan Water Board, through Mr. Charles W. Sherman, assistant engineer:

Average yield per square mile of Mystic Lake watershed, 1878 to 1897, inclusive.

[Drainage area, 26.9 square miles.]

Month.	Second-feet per square mile.	Run-off in inches.	Rainfall in inches.	Per cent.
January	1.81	2.09	4.21	49.5
February	2.72	2.86	4.04	70.8
March	3.39	3.91	3.72	105 2
April	2.33	2.61	3.02	86.1
May	1.62	1.87	3.64	51.5
June	.96	1.07	3.20	33.5
July	.49	.56	3.58	15.6
August	.56	.65	4.00	16.3
September	.47	.52	3.17	16.4
October	.69	.80	3.98	20.1
November	1.14	1.28	3.79	33.7
December	1.41	1.63	3.47	46.9
The year	1.46	19.85	43.82	45.3

Records are not available after 1897, although observations have been continued. The watershed is no longer in use as a source of supply, and so many complications enter into an estimate of yield that it is probable that it will not be computed.

Run-off in inches on Mystic Lake watershed, 1878 to 1897, inclusive.

[Drainage area, 36.9 square miles.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1878	3.35	3.97	4.91	2.25	2.16	0.79	0.48	1.11	0.56	0.71	1.75	3.63	25.82
1879	1.21	2.23	3.31	3.97	1.95	.97	.54	.79	.68	.34	.63	.69	16.94
1880	1.79	2.54	1.95	1.50	.96	.52	.67	.54	.65	.36	.44	.59	12.21
1881	.62	2.14	4.79	2.17	1.51	2.05	.87	.35	.31	.29	.50	.87	18.47
1882	1.37	3.03	4.19	1.16	1.65	.61	.35	.22	.53	.58	.39	.57	15.66
1883	.79	1.43	1.80	1.65	1.39	.52	.30	.22	.18	.39	.42	.44	9.31
1884	1.69	3.89	5.62	3.65	1.69	.95	.58	.60	.23	.27	.35	1.17	20.18
1885	1.79	1.81	2.05	2.03	2.19	.80	.47	.54	.34	.68	2.41	2.39	17.55
1886	2.31	7.79	3.91	3.24	1.27	.55	.41	.25	.32	.38	.88	1.43	22.65
1887	2.16	3.41	3.40	3.75	1.49	1.27	.87	1.25	.64	.57	.71	.91	22.17
1888	1.43	3.32	4.29	3.37	2.00	.44	.39	.34	1.31	2.74	5.04	5.08	31.12
1889	4.51	1.83	1.60	2.27	2.18	1.89	1.33	2.05	1.06	1.21	2.49	3.06	25.48
1890	2.07	2.23	5.37	2.93	3.00	1.92	.43	.46	.56	2.61	1.95	2.49	28.04
1891	6.29	5.97	7.21	3.43	1.49	1.91	.42	.44	.42	.58	.50	.87	28.60
1892	2.49	1.76	3.05	1.33	2.10	1.17	.68	.49	.56	.45	1.07	.87	15.98
1893	.73	2.14	4.32	2.72	4.02	1.04	.47	.69	.41	.55	.71	1.27	19.69
1894	1.37	1.87	3.05	2.27	1.31	.91	.49	.38	.36	.58	.91	.90	14.40
1895	1.55	.87	3.16	2.95	1.13	.54	.60	.80	.36	1.46	2.37	2.12	17.91
1896	1.85	3.40	4.50	3.26	.77	.75	.39	.34	1.08	.89	1.11	1.23	19.55
1897	1.39	1.40	3.46	2.14	1.83	2.19	.50	.95	.41	.39	1.02	1.96	17.64
Mean	2.09	2.86	3.91	2.61	1.67	1.07	.56	.65	.52	.80	1.28	1.63	13.85

CONNECTICUT RIVER AT HOLYOKE, MASSACHUSETTS.

This river, rising in northern New Hampshire and Vermont, flows in a general southerly course, forming the greater part of the boundary between these States, and crosses Massachusetts and Connecticut, emptying into Long Island Sound. Computations of discharge have been made in the southern part of its course at Holyoke, Massachusetts, a short distance above the Connecticut State line. The flow of the river is controlled at this point by the Holyoke Water Power Company. Data of stream flow have been obtained from Mr. A. F. Sickman, assistant engineer of the company. The quantities given are the daily amounts drawn from the pond above the dam, representing the discharge of the river excepting at such times as the surface falls below the crest, when water is ponded over night and Sunday. The results by months, from 1880 to 1895, are published in Bulletin No. 140, pages 37 to 41; for 1896 and 1897, in the Nineteenth Annual Report, Part IV, page 116; and for 1898, in the Twentieth Annual Report, Part IV, page 76.

aily mean discharge in second-feet of Connecticut River at Holyoke, Massachusetts.

[Drainage area, 8,660 square miles.]

1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	47,350	5,500	66,950	34,400	18,300	6,550	3,900	2,300	2,700	4,650	12,050	17,900
2	39,050	4,850	112,050	38,100	16,050	6,350	3,800	2,450	2,850	4,700	11,750	15,750
3	29,700	5,350	103,450	32,300	14,700	6,450	2,350	3,900	2,700	3,600	11,550	12,300
4	23,850	4,850	65,050	24,650	15,000	6,200	750	3,700	2,700	3,500	12,100	8,250
5	12,200	4,800	37,900	19,600	14,350	5,800	1,700	3,750	2,100	4,550	12,800	6,450
6	9,300	5,550	25,100	18,550	13,900	4,650	2,050	3,650	700	4,600	26,800	6,500
7	7,750	17,150	22,050	18,350	13,700	3,850	2,900	3,800	6,150	5,200	30,450	8,550
8	7,300	20,750	19,050	17,550	13,550	5,100	3,450	2,850	7,750	5,250	25,300	8,850
9	7,600	19,700	17,950	17,700	11,900	4,900	4,450	4,100	8,050	5,550	23,900	9,700
10	7,850	17,700	16,900	19,900	11,000	7,100	6,050	4,650	7,200	4,750	21,000	13,900
11	7,100	14,300	14,050	22,700	11,050	8,850	4,500	4,000	6,450	4,300	17,650	13,800
12	7,250	11,650	10,900	26,950	10,700	8,750	4,300	3,750	4,800	4,500	15,800	11,000
13	8,250	10,600	9,350	37,300	10,700	7,750	4,150	3,750	3,900	4,250	15,050	10,400
14	8,250	9,600	9,300	59,350	11,000	6,450	4,100	3,800	4,400	6,600	12,550	9,900
15	7,700	8,750	8,900	71,100	11,000	6,600	4,000	2,050	4,100	10,200	11,600	9,350
16	7,900	7,600	8,550	77,500	9,050	5,950	4,150	1,300	3,800	20,100	11,400	5,950
17	7,700	7,800	8,950	84,450	7,800	5,700	4,100	2,800	3,650	16,850	10,700	4,300
18	5,800	6,400	10,350	89,200	7,650	5,050	2,650	2,800	3,450	14,750	10,000	4,650
19	6,450	6,250	10,750	88,600	7,700	5,050	450	2,800	2,350	13,950	9,650	5,000
20	7,400	6,600	25,250	81,200	7,350	4,250	4,200	2,800	4,650	13,300	9,150	5,150
21	7,100	6,400	29,250	71,050	7,150	3,500	3,900	2,800	6,200	14,150	7,900	6,050
22	7,100	5,550	25,150	61,950	6,900	4,300	3,400	2,800	6,850	18,300	8,150	5,250
23	6,950	5,150	22,300	54,600	5,900	4,400	3,700	550	8,450	22,100	9,450	4,750
24	6,900	6,550	18,400	46,450	5,650	4,450	4,300	3,300	8,100	21,850	8,750	3,900
25	6,200	6,800	15,300	38,300	6,050	4,300	4,150	3,350	6,850	20,500	8,400	3,650
26	6,000	6,500	15,050	30,800	5,800	4,350	4,100	3,300	4,550	19,500	10,500	4,200
27	6,800	6,300	19,750	26,750	5,850	2,550	4,550	2,950	4,250	16,800	13,300	3,400
28	6,350	6,100	23,250	23,150	4,850	3,300	4,450	2,700	4,500	14,500	13,600	4,550
29	6,100	9,600	22,250	20,900	5,350	4,050	4,300	1,900	4,450	13,000	14,600	4,400
30	6,100	.....	24,050	19,500	5,150	4,150	4,350	450	4,400	12,050	17,550	4,250
31	6,000	.....	26,150	.....	5,100	.....	4,000	2,800	.....	12,200	.....	4,300
Mean	10,882	9,096	27,216	42,363	9,684	5,357	3,684	2,965	4,768	10,971	14,115	7,624

1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3,350	3,900	4,400	21,900	32,950	22,900	10,200	22,350	6,200	4,950	3,850	21,050
2	3,350	3,600	3,550	22,950	27,800	19,300	9,550	18,950	6,150	3,450	4,550	16,650
3	3,350	3,600	3,500	25,150	28,000	16,750	9,900	16,050	5,300	3,350	17,050	12,800
4	4,700	3,750	4,450	24,600	27,100	16,100	9,550	13,950	4,550	5,000	19,400	10,700
5	4,700	4,300	5,700	27,050	27,500	18,100	8,100	12,800	4,600	4,350	15,850	11,150
6	7,550	2,950	7,550	37,100	26,350	19,600	7,650	12,750	4,800	3,400	13,200	16,800
7	10,100	2,550	11,750	46,250	23,900	20,350	7,950	10,550	4,650	3,150	10,100	15,600
8	10,350	11,100	12,150	44,900	20,550	19,050	9,950	8,750	4,500	3,250	9,850	18,700
9	8,400	13,600	10,550	42,150	17,050	20,200	13,200	8,950	4,450	2,950	9,150	16,850
10	8,600	14,250	10,250	45,150	16,150	60,600	11,950	8,400	4,450	1,300	14,900	16,500
11	7,500	11,150	12,550	36,250	14,500	75,350	9,350	9,150	3,650	3,550	18,050	15,850
12	6,650	8,400	15,700	31,350	15,400	56,950	8,550	13,650	2,550	3,000	17,850	16,650
13	5,900	6,500	15,300	26,600	17,500	41,300	13,050	12,600	5,050	3,900	16,200	22,950
14	5,100	7,250	13,050	25,550	35,800	35,300	37,000	10,200	3,900	5,100	13,700	23,600
15	4,750	6,150	12,250	28,700	44,050	30,000	57,250	8,150	3,450	5,300	12,900	59,850
16	3,750	5,100	10,300	41,300	36,550	24,500	58,350	9,600	3,450	4,400	11,550	70,650
17	3,450	5,200	9,150	48,550	30,000	21,050	50,200	9,150	4,000	2,050	15,400	63,850
18	5,100	5,250	8,200	50,950	24,900	17,800	39,350	11,050	3,700	4,900	19,300	52,600
19	4,900	4,950	8,100	49,350	19,700	15,250	31,350	12,300	2,250	4,700	17,700	37,050
20	4,900	3,950	15,650	44,500	16,850	12,300	23,250	11,800	3,700	4,350	14,600	25,550
21	4,400	3,600	23,750	39,700	14,600	13,300	18,750	9,750	3,550	3,900	12,700	18,950
22	4,700	4,950	23,750	34,500	13,600	13,800	17,550	9,050	3,550	4,650	12,650	15,750
23	3,350	4,900	25,850	30,250	12,450	12,750	19,350	8,650	3,950	2,900	12,350	14,100
24	3,000	4,800	34,650	27,300	13,400	11,250	21,400	8,750	4,650	3,050	11,150	13,200
25	4,100	4,850	33,350	29,050	14,050	10,000	20,550	9,400	4,450	4,400	8,250	10,350
26	3,500	4,850	25,850	34,650	16,250	8,300	21,100	9,700	4,050	3,750	9,000	8,950
27	3,350	3,700	18,600	37,350	18,950	7,900	27,300	9,500	5,150	3,700	22,050	10,450
28	3,600	2,700	16,750	37,250	20,350	9,950	24,800	7,850	4,950	3,150	29,550	10,450
29	4,200	.....	16,350	36,950	23,050	9,700	44,150	7,050	4,900	3,100	28,300	9,550
30	2,300	.....	16,250	37,050	24,600	9,900	53,650	7,250	4,850	3,050	25,250	9,050
31	2,400	.....	19,350	.....	24,350	.....	32,900	6,450	.....	1,750	.....	8,950
Mean	5,011	5,780	14,471	35,478	22,524	22,320	23,458	10,792	4,313	3,668	14,880	21,779

Daily mean discharge in second-feet of Connecticut River at Holyoke, Massachusetts—Continued.

1898.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7,650	7,000	8,100	43,500	23,800	14,300	6,000	4,750	5,000	6,300	16,250	12,050
2	7,500	6,600	8,400	37,300	22,150	12,950	6,050	3,800	4,650	4,650	14,050	12,600
3	7,700	7,050	8,050	29,550	20,450	11,550	5,600	3,450	3,600	5,600	12,700	11,500
4	7,650	7,350	8,050	25,850	20,550	10,250	4,800	3,650	3,550	5,050	11,550	11,100
5	7,750	6,900	7,500	22,450	22,100	8,650	4,550	4,700	4,000	6,600	10,700	14,150
6	7,650	6,350	6,950	20,450	22,650	9,200	4,250	4,350	5,500	23,000	8,950	15,250
7	8,100	7,500	7,800	19,400	20,850	9,000	3,300	4,800	6,850	15,500	10,350	14,800
8	9,050	7,350	8,000	18,400	17,950	8,800	3,450	6,250	6,550	12,550	9,850	13,050
9	8,600	7,350	8,550	16,950	17,300	8,000	3,850	6,150	5,950	12,200	9,700	11,550
10	8,750	7,650	9,650	16,050	15,600	8,050	2,850	5,750	5,050	11,650	10,850	12,250
11	8,450	7,850	11,750	18,650	14,400	7,600	4,400	5,450	3,550	9,550	28,750	9,900
12	8,300	8,100	16,950	20,000	14,400	8,300	4,250	4,800	5,050	8,600	29,150	9,400
13	8,750	9,250	30,700	21,950	18,250	10,500	3,850	4,000	4,850	7,800	21,350	5,800
14	13,150	12,250	66,500	23,950	22,000	15,000	3,450	3,150	3,500	7,200	18,800	5,850
15	12,300	12,450	74,900	26,300	22,450	17,900	3,600	4,750	3,900	7,200	16,600	6,150
16	15,450	11,750	64,700	35,750	23,850	17,000	3,200	3,800	4,700	9,800	14,950	6,400
17	14,700	10,400	53,500	37,000	22,500	15,850	600	3,500	3,550	11,550	13,700	6,050
18	11,850	9,900	50,750	34,200	19,200	13,800	4,050	3,450	650	10,400	13,500	6,600
19	10,000	9,350	55,850	31,500	16,550	12,200	3,350	4,600	4,200	10,150	16,200	7,250
20	9,700	8,750	59,750	28,500	15,150	14,800	3,500	3,950	3,550	11,950	24,550	6,500
21	12,950	9,850	76,150	27,350	14,500	14,350	3,250	4,550	3,400	12,650	26,650	6,500
22	16,050	9,350	68,600	25,400	12,350	13,800	3,200	5,350	3,300	13,250	23,750	7,200
23	14,650	9,250	52,100	23,300	12,450	12,800	3,200	4,850	3,200	16,000	20,700	8,550
24	15,000	9,200	49,050	28,450	13,050	11,750	2,250	4,750	3,000	15,450	18,000	11,550
25	13,100	9,000	44,250	46,850	14,550	10,500	4,100	6,700	6,950	13,450	16,450	12,300
26	11,300	8,800	37,900	50,450	23,300	9,050	4,350	7,550	12,000	12,050	14,200	12,650
27	10,500	7,650	35,450	46,700	23,600	9,750	4,450	5,850	12,550	17,850	12,750	11,000
28	9,700	8,600	38,500	39,200	26,800	9,100	4,600	4,950	12,050	22,400	10,850	9,650
29	8,500	.....	41,550	33,500	22,350	8,500	4,500	6,950	10,050	21,000	8,850	8,450
30	8,050	.....	43,900	28,450	19,450	7,550	3,400	6,950	8,000	18,700	10,550	7,600
31	7,650	.....	46,100	.....	16,900	.....	1,500	6,150	.....	18,300	.....	7,700
Mean	10,339	8,673	35,482	29,245	19,079	11,395	3,798	4,958	5,423	12,207	15,840	9,689

The figures for 1899 have not been computed at this time, April, 1900.

CONNECTICUT RIVER AT HARTFORD, CONNECTICUT

Observations of the height of Connecticut River are maintained at a point near Hartford by the Connecticut River Bridge and Highway District, Edwin D. Graves, chief engineer, as noted in the Twentieth Annual Report, Part IV, page 77. Daily readings, beginning February 8, 1896, have been obtained, and are given below. Computations of discharge of the river at this point from 1871 to 1886 have been printed in the Fourteenth Annual Report, Part II, beginning on page 140. The gage now being read was placed at the same elevation as the old gage established by the Engineer Corps, United States Army, about 1872.

ily noon gage height in feet of Connecticut River at Highway Bridge, Hartford, Connecticut.

1896.

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	.....	18.0	10.6	7.7	3.5	2.5	1.7	1.5	3.0	3.7	7.0
.....	.....	20.0	11.3	7.6	3.7	2.0	1.5	1.5	2.8	3.6	6.8
.....	.....	26.5	12.0	7.0	3.7	2.1	1.6	1.9	2.7	3.7	6.0
.....	.....	25.6	11.6	6.5	3.5	2.2	2.4	2.4	2.5	4.0	5.5
.....	.....	20.0	10.0	6.4	3.5	2.3	2.0	2.7	2.4	4.8	4.4
.....	.....	16.0	9.5	6.0	3.3	2.3	1.8	3.3	3.0	6.0	3.2
.....	.....	13.0	9.0	5.8	3.0	2.3	2.5	3.6	4.1	10.0	4.0
.....	12.5	9.0	8.5	5.7	2.6	2.3	1.7	4.4	3.2	10.6	4.0
.....	12.5	7.8	7.6	5.7	3.0	2.4	2.0	4.0	3.3	10.0	5.0
.....	11.4	6.3	7.5	5.5	3.0	2.4	2.6	3.6	3.4	7.6	5.0
.....	10.3	5.3	7.8	5.2	3.5	2.4	2.7	4.3	3.4	7.4	6.5
.....	9.0	4.8	8.3	5.0	4.0	2.4	2.4	4.0	3.7	6.7	6.4
.....	7.3	4.4	10.0	4.6	4.4	2.4	2.4	3.6	3.8	6.4	5.3
.....	6.5	4.5	12.0	4.6	4.5	2.0	1.8	3.4	4.4	6.0	5.0
.....	6.3	4.5	15.0	4.7	4.4	2.4	1.9	2.8	5.0	5.5	4.8
.....	6.3	4.5	16.0	4.7	4.3	2.5	2.0	2.3	4.9	5.0	4.7
.....	6.3	4.6	18.0	4.2	4.0	2.7	1.8	2.4	4.7	4.5	2.5
.....	6.3	4.8	20.8	3.5	3.7	2.5	1.7	2.0	4.5	4.0	4.0
.....	6.3	4.9	22.0	3.4	3.7	1.5	1.6	2.3	4.4	4.0	4.5
.....	6.0	8.0	22.2	3.7	3.2	.6	1.5	2.7	4.0	3.8	4.6
.....	5.3	10.8	21.0	3.5	3.0	1.3	1.5	3.2	4.0	4.0	4.7
.....	5.3	11.4	19.8	3.4	2.4	2.0	1.5	3.5	4.0	4.0	4.5
.....	5.5	10.0	18.4	3.0	2.4	2.2	1.6	3.4	4.8	4.0	4.3
.....	5.9	9.0	17.0	2.8	2.5	2.0	1.6	3.4	5.2	4.5	4.2
.....	6.0	8.0	15.5	3.6	2.0	2.6	1.7	3.4	5.7	4.0	3.9
.....	6.0	7.0	13.5	3.3	2.4	2.7	1.5	3.3	6.0	4.6	3.7
.....	11.0	6.0	11.0	3.0	2.6	2.7	1.5	3.5	5.5	5.0	3.5
.....	14.0	6.9	11.0	3.4	2.8	2.8	1.5	3.6	5.0	5.5	4.0
.....	16.5	8.9	9.0	3.4	3.0	2.7	1.5	3.7	5.0	5.9	3.5
.....	.....	9.5	8.0	3.5	2.0	2.6	1.6	4.0	5.0	6.5	4.0
.....	.....	9.8	.....	3.5	.....	2.5	1.6	.....	4.0	.....	3.5

1897.

3.4	3.7	3.8	8.8	13.5	10.0	5.0	17.0	4.3	2.5	3.0	9.5
3.4	3.8	4.0	9.6	12.4	9.0	5.1	13.0	3.8	3.3	3.9	8.0
3.4	3.9	3.8	9.8	11.7	8.0	5.0	10.5	4.6	3.5	5.0	6.8
3.4	4.5	4.8	10.2	11.0	8.0	4.8	8.6	3.9	3.0	8.0	6.0
4.8	4.0	5.0	10.5	11.4	7.0	4.8	8.5	3.5	2.7	7.3	6.0
5.9	3.8	6.5	12.2	11.0	8.0	4.5	8.2	3.3	2.6	6.8	7.4
5.7	4.1	7.0	13.5	10.3	6.7	4.2	7.7	3.3	2.7	5.6	10.0
5.6	6.8	8.2	15.5	9.3	8.6	4.0	6.7	3.3	2.8	4.7	9.7
5.5	9.4	7.5	15.3	7.6	7.1	5.0	5.5	2.8	2.8	4.6	8.8
5.5	9.5	6.8	17.4	7.4	12.0	5.8	5.5	2.8	2.0	4.7	8.0
4.5	9.0	7.1	17.0	7.0	18.0	5.0	5.0	3.3	1.6	5.5	8.0
5.0	8.1	8.0	15.2	6.5	20.6	4.6	7.2	3.0	3.0	8.0	8.0
4.5	7.0	9.0	13.7	7.0	18.3	5.0	8.2	3.0	2.5	8.5	9.1
3.9	6.4	8.9	11.4	9.6	16.3	11.5	7.0	3.2	2.8	7.8	11.5
3.5	5.7	8.8	10.8	15.0	13.8	18.6	6.2	2.8	3.0	6.8	14.0
4.0	5.8	7.8	11.0	14.7	12.0	20.8	5.0	3.0	3.0	6.0	19.6
3.0	5.4	6.7	15.0	14.0	10.1	20.0	6.8	3.0	2.6	5.8	20.4
3.4	5.2	5.6	16.5	12.1	9.0	18.3	6.9	3.0	2.4	6.5	19.0
3.5	5.5	5.6	17.3	10.5	8.0	16.8	6.0	2.9	2.8	7.5	16.0
3.8	5.4	7.8	16.7	9.4	7.2	14.0	6.0	2.8	3.0	7.6	13.0
4.3	5.3	10.0	15.6	8.0	6.0	10.0	6.5	2.8	3.7	7.1	9.4
4.5	5.2	11.0	14.5	7.9	6.0	9.0	5.0	2.6	4.0	6.5	8.0
3.9	5.9	11.0	13.0	6.8	6.0	12.2	5.3	2.7	3.7	6.0	6.5
3.5	6.2	12.2	11.8	6.4	5.8	12.7	5.2	3.0	3.6	5.5	5.5
3.2	5.6	13.8	11.8	6.3	5.3	12.7	4.9	3.0	3.2	5.0	6.2
2.7	5.0	12.8	12.0	6.7	4.6	11.5	5.2	3.0	2.7	5.3	7.5
2.6	5.0	11.4	13.3	7.0	4.4	10.2	6.0	3.0	4.0	6.0	8.5
2.8	4.0	9.8	13.5	8.0	3.8	12.0	5.2	3.0	3.0	9.0	8.6
3.0	.....	8.5	13.4	8.6	4.4	12.4	5.6	2.9	3.0	11.0	8.6
3.6	.....	7.8	13.5	9.2	4.7	19.3	4.2	3.4	3.0	10.4	8.6
3.7	.....	8.0	.....	10.0	.....	20.6	4.5	.....	3.0	.....	8.4

Daily noon gage height in feet of Connecticut River at Highway Bridge, Hartford, Connecticut—Continued.

1898.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	8.0	7.8	6.0	15.4	13.2	8.0	4.5	4.0	3.7	5.0	8.1
2	7.7	7.8	5.8	15.5	12.5	7.0	4.2	4.0	3.2	4.0	7.4
3	7.5	7.8	5.6	13.8	11.6	6.7	4.0	4.3	3.0	4.5	6.6
4	7.4	7.7	5.4	12.4	10.9	6.4	4.0	4.6	3.0	3.2	6.3
5	7.2	7.6	5.0	10.5	10.0	6.2	4.0	4.5	3.0	4.0	5.8
6	6.9	7.5	4.6	9.9	10.4	6.0	3.8	4.4	3.2	6.1	5.6
7	6.8	7.4	4.9	9.4	10.5	5.8	3.4	4.2	3.4	9.0	5.4
8	7.5	7.3	5.4	9.0	9.8	5.6	3.0	4.0	3.7	6.0	5.1
9	7.4	7.3	5.8	8.6	9.0	4.8	3.0	3.9	3.6	5.8	5.3
10	7.3	7.5	6.4	8.5	8.4	4.7	2.8	4.0	3.7	5.6	5.0
11	7.2	7.5	6.8	8.4	7.9	4.5	2.7	3.8	3.4	5.1	8.6
12	7.0	7.4	8.0	8.7	7.6	4.7	2.6	3.2	3.0	5.0	13.0
13	6.8	8.5	10.8	9.0	8.0	5.0	2.4	3.5	3.0	4.5	12.0
14	8.1	9.7	17.4	9.5	9.6	6.5	2.2	3.4	3.2	5.0	10.0
15	9.5	9.8	20.0	9.7	9.8	8.0	2.0	3.2	3.2	5.5	9.0
16	9.8	9.0	21.0	10.0	10.2	7.7	1.9	3.0	3.4	5.8	7.9
17	9.8	8.4	20.0	12.0	10.4	7.4	1.8	2.7	3.0	6.0	7.6
18	8.8	7.6	19.0	14.5	10.2	7.0	1.6	2.6	2.5	5.8	7.2
19	7.5	7.8	18.0	13.0	9.0	7.2	3.0	2.6	2.0	5.5	10.0
20	6.0	8.2	18.8	12.2	8.2	7.4	3.1	4.0	2.2	5.7	11.3
21	8.2	12.0	19.1	11.6	7.8	7.5	3.1	4.6	3.2	6.3	12.4
22	10.0	12.0	21.2	12.5	7.3	7.0	3.3	3.9	2.4	7.2	11.7
23	10.6	10.3	20.5	13.5	6.8	6.5	3.3	3.7	3.2	7.1	10.7
24	11.4	9.0	18.2	14.5	7.4	6.0	3.4	3.4	3.0	7.0	9.6
25	10.4	7.8	17.3	15.5	8.0	5.8	3.5	4.4	4.5	7.2	9.0
26	9.0	6.8	16.5	16.5	10.0	5.5	3.5	5.2	5.5	6.6	8.2
27	9.0	6.5	15.5	17.0	11.2	5.4	3.6	4.9	6.3	7.1	7.5
28	8.5	6.0	14.5	16.5	13.6	5.1	3.7	4.0	6.6	9.7	6.4
29	7.8	.....	14.8	14.9	12.7	4.8	3.8	4.0	6.3	9.7	6.1
30	7.5	.....	15.3	14.0	11.8	4.5	3.8	4.3	5.0	9.2	6.0
31	7.0	.....	15.4	.....	10.3	.....	3.9	4.5	.....	8.7	.....

1899.

1	7.5	6.0	8.7	9.2	19.3	4.0	2.7	3.1	2.2	1.5	4.5
2	7.6	5.7	8.7	9.3	18.4	4.0	2.7	2.5	3.0	.6	4.7
3	7.7	5.6	8.5	9.5	18.1	4.0	2.8	3.0	2.7	.8	4.8
4	7.7	5.4	7.5	9.2	18.0	3.7	2.9	2.9	2.9	1.9	4.9
5	7.8	5.5	7.2	8.5	17.0	3.4	2.9	3.4	3.0	2.2	5.0
6	10.2	5.7	8.7	8.6	15.8	3.3	3.0	3.6	2.8	2.1	5.0
7	11.5	5.6	9.8	9.0	14.0	3.2	3.0	2.5	2.7	2.1	5.0
8	11.0	6.2	9.0	11.0	12.5	3.7	3.0	2.5	2.7	2.0	4.5
9	10.5	5.6	8.6	13.1	10.9	3.0	3.1	2.6	2.8	2.0	4.4
10	8.0	5.0	8.0	15.4	9.4	3.0	3.1	2.2	2.5	2.5	4.3
11	8.5	4.5	7.5	15.1	8.5	3.0	3.2	3.2	2.2	2.5	4.2
12	8.6	4.5	8.5	14.5	8.0	3.0	3.2	3.2	2.3	2.5	4.1
13	8.2	4.5	9.7	15.1	7.5	2.7	2.5	3.2	2.3	2.4	4.0
14	8.0	4.7	11.0	15.5	7.0	2.6	2.6	2.8	2.8	2.5	4.5
15	8.1	5.0	11.0	18.5	6.5	2.6	2.6	2.2	2.4	2.7	4.0
16	8.2	5.2	11.2	20.0	6.5	2.6	2.7	2.6	3.2	2.8	3.5
17	8.5	5.5	10.5	21.5	6.2	3.0	2.7	3.4	2.8	2.9	3.5
18	10.0	5.5	9.5	20.6	6.0	3.0	2.7	3.5	2.8	3.0	3.5
19	9.5	5.5	9.7	20.2	5.7	3.0	2.8	3.2	2.4	2.5	3.4
20	8.5	6.0	10.1	20.5	5.5	3.0	2.9	3.4	2.7	2.0	3.4
21	7.9	6.5	9.2	21.5	5.5	3.0	2.9	3.2	2.6	2.2	3.4
22	7.3	6.6	8.4	21.2	5.5	3.0	3.0	3.0	3.2	2.4	3.6
23	6.8	6.8	7.8	20.9	5.5	3.4	3.0	2.6	3.5	2.6	3.7
24	7.0	7.2	7.7	20.8	5.2	3.3	3.1	2.2	3.1	2.8	3.9
25	8.0	7.1	7.4	21.3	5.2	3.2	3.0	3.0	2.7	3.0	4.0
26	8.0	7.7	7.0	21.6	4.6	3.1	4.2	2.7	3.0	3.0	4.5
27	8.0	7.7	6.5	22.0	4.5	3.0	3.7	2.6	3.0	3.0	5.0
28	7.5	8.5	6.5	21.9	4.3	2.9	4.4	2.5	2.8	4.0	5.0
29	7.0	.....	7.5	21.0	4.2	3.2	4.2	3.2	3.1	4.1	5.0
30	6.5	.....	8.8	20.0	4.5	2.7	3.0	3.2	3.0	4.2	3.4
31	6.2	.....	9.0	.....	4.3	.....	2.5	2.8	.....	4.3	.....

MOHAWK RIVER AT RIDGE MILLS, NEW YORK.

Mohawk River rises in Lewis County, New York, and flows southerly hrough Oneida County, and turning to the east finally empties into Hudson River. It is shown through the greater portion of its length on the Oneida, Oriskany, Utica, Fonda, Amsterdam, Schenectady, and Cohoes topographic sheets of the United States Geological Survey. The measurements on this stream and its tributaries were nstituted as previously described on page 20 by Mr. George W. Rafter for the United States Board of Engineers on Deep Waterways. The station at Ridge Mills is located at the dam of the Rome waterworks, 3 miles above Rome. The drainage area of the Mohawk River at this point is 153 square miles. Two gages are read twice a day by Daniel Brown, engineer at pumping station—one above the dam showing the height on the crest and one in the tailrace in order to determine the head on the wheels. The crest of the dam has an irregular profile, and in order to facilitate computation is divided into three parts. The flow over section *A* was computed from Bazin's experiments of November and December, 1895, series No. 162, with $q=8.025\ mLH^{\frac{3}{2}}$. The flow over sections *B* and *C*, which is over flashboards, is computed from Francis's formula for sharp-crested weirs. Experiments were conducted at Cornell University on an experimental weir corresponding to Bazin's series No. 162, and from the coefficients obtained a discharge curve plotted to correspond with the discharge curve of Bazin's. All computations of flow at this point made before June 1, 1899, were made by using Bazin's coefficients, but in subsequent computations the Cornell coefficients were used. The dam is of timber, backed with stone, and has very little leakage.[1]

[1] On flow of water over dams, by George W. Rafter: Proc. Am. Soc. Civ. Eng., March, 1900, Vol. XXVI, No. 3, p. 311.

Estimated daily discharge in second-feet of Mohawk River at Ridge Mills, York, for 1899.

[Drainage area 153 square miles.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	339	262	218	.....	93	75	339
2	319	252	233	.....	203	75	75
3	279	232	248	.....	233	105	75
4	259	249	131	.....	253	135	129
5	214	202	146	.....	200	95	158
6	232	127	131	.....	310	135	158
7	232	262	126	.....	290	145	172
8	262	322	121	.....	260	135	190
9	259	669	125	85	290	135	575
10	279	499	129	85	310	165	575
11	249	379	139	85	340	125	147
12	282	359	169	95	260	135	.....
13	282	339	265	89	310	145	.....
14	302	339	245	85	260	145	.....
15	402	319	275	99	310	145	.....
16	399	399	295	115	240	145	115
17	359	519	230	135	220	135	158
18	339	399	230	112	290	135	158
19	282	382	245	85	290	145	.....
20	279	339	245	79	290	165	.....
21	262	302	265	79	240	165	.....
22	259	382	295	56	260	145	151
23	299	299	272	56	260	145	151
24	259	282	289	56	310	145	129
25	259	275	262	60	540	135	151
26	259	262	269	69	220	145	172
27	249	289	309	69	310	135	172
28	249	165	309	53	340	165	172
29	249	133	278	53	360	.....	172
30	229	178	315	79	260	.....	339
31	.....	178	200	.....	260	.....	339
Mean	281	310	226	81	278	136	207

NINEMILE CREEK AT STITTVILLE, NEW YORK.

This stream rises in the northern part of Oneida County, New Yo and flows south into Mohawk River. A portion of its course is sho on the Oneida topographic sheet of the Geological Survey. Obs vations were made on this creek at Stittville, which is reached by Rome, Watertown and Ogdensburg Railroad. The drainage are Ninemile Creek at Stittville is 63 square miles. The station located at an old timber dam built to furnish power to a gristı and sawmill. One gage was read at the bridge above the dam, giv the height on crest, and one at tailrace below the dam, which, with upper gage, gave the head on wheels. The dam had a somewhat irı ular crest, but was repaired by the Board on Deep Waterways. flow over section *A*, which is the bulkhead, is computed from Baz experiments in October, 1887, series No. 115, with $q=8.025mL$ The flow over section *B*, which is a spillway, is computed from Baz experiments of July, 1894, series 130, with $q=8.025mLH^{\frac{3}{2}}$. A ı curve was later drawn, based upon experiments carried on at Corı University, corresponding to Bazin's series, Nos. 115 and 120. T dam leaks badly, so that low-water flows are of questionable accura There are in the mill two standard Leffel wheels, one a 23-inch wh and the other a 40-inch wheel, and a record was kept of the head

e wheels and the amount of openings, so that the quantity of water ssing through the wheels can be computed. The results obtained om this station were of such questionable accuracy that the station as abandoned on June 30, 1899.

ORISKANY CREEK AT COLEMAN, NEW YORK.

This stream rises in Oneida County, New York, and flows in a ortherly direction, emptying into Mohawk River. It is shown hrough a part of its course on the Oriskany topographic sheet of the Jnited States Geological Survey. Observations for the computation f flow of Oriskany Creek have been made at Coleman, 5 miles above he junction of the creek with Mohawk River, and at Oriskany, 2 niles farther down. The station at Coleman was located at Reeders Mills. The dam located here impounds water to furnish power for he picking mill and cotton mill on the west bank and for the gristnill and sawmill on the east bank. The gages were read above he dam, giving the height on crest, and in the headraces and tailraces f each of the mills, giving the heads on wheels. The dam is of earth, vith a timber crest, irregular in profile. For convenience in compuation the crest has been divided into nine parts. The flow over this lam was computed from Bazin's experiments of November, 1895, series No. 170. The station was established September 20, 1898, and coninued until February 28, 1899, when it was abandoned.

ORISKANY CREEK AT ORISKANY, NEW YORK.

The drainage area of Oriskany Creek at this station is 144 square niles. The flow is measured over the State dam, the gage showing the eight on crest being located on the left bank just above the dam. The rest is of irregular profile, and in order to facilitate computation is ivided into three parts. No experiments have been made to deterine coefficients for a dam of this section, so it was considered by Ir. George W. Rafter that the mean between the coefficients obtained y Bazin in his experiments, series Nos. 141 and 117, would best fit he conditions at this dam. Experiments were afterwards conducted t Cornell University on a similar section. For a cross section of his dam reference should be made to the paper on "Flow of water ver dams," by George W. Rafter: Proc. Am. Soc. Civ. Eng., March, 900, p. 312. All computations of discharge up to June 1 were made rom coefficients as determined by Bazin; all subsequent observaions have been computed by using the Cornell coefficients. Water assing through the Erie Canal feeder is determined by knowing the elative heights of the gage above the dam and of the one below the gates in the feeder. The difference between these two readings gives the head on the gate. The stem of the gates is marked so that the

amount of openings at any time can be determined. Readings the two gages and the two gate stems are made twice a day by Fra Baker.

Estimated daily discharge in second-feet of Oriskany Creek at Oriskany, N York, for 1898.

[Drainage area, 146 square miles.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	80	(a)	290	85	140	220	90
2	80	(a)	290	87	126	175	105
3	80	(a)	197	73	105	115	73
4	80	(a)	126	10	90	126	100
5	80	(a)	126	75	119	144	80
6	80	120	177	100	132	346	107
7	80	194	177	101	122	374	99
8	80	170	195	132	126	429	40
9	80	194	195	170	95	364	30
10	80	160	195	240	38	394	10
11	80	157	195	159	106	624	45
12	94	124	195	95	97	534	340
13	80	124	195	73	92	564	330
14	96	124	195	87	26	564	80
15	106	124	290	65	72	564	65
16	101	290	290	80	45	484	80
17	96	300	290	115	106	524	40
18	123	197	290	125	30	564	65
19	123	195	290	119	71	202	250
20	123	195	290	139	48	53	130
21	123	270	290	101	82	154	110
22	123	270	290	129	73	154	50
23	124	270	290	107	85	174	50
24	124	196	290	102	99	214	70
25	124	196	290	112	70	174	50
26	124	196	194	183	70	428	40
27	124	196	194	225	54	318	30
28	123	196	194	216	156	318	35
29	123	196	194	185	72	582	30
30	123	196	98	206	55	789	65
31		196	98		115		70
Mean	99	180	146	126	91	300	89

a No record July 1 to 5.

SAUQUOIT CREEK AT NEW YORK MILLS, NEW YORK.

This creek rises in Oneida County, New York, and flows in a nort erly direction, emptying into Mohawk River. It is shown in a part its course on the Oriskany topographic sheet of the United States G logical Survey. Observations of flow are made on this creek at N York Mills, at which point the creek has a drainage area of 52 squ miles. One gage is located at the dam, which furnishes power mill No. 3, and is read by E. D. Cronk. A gage in the headrace n the mill wheels and one in the tailrace, are read by Robert Hugh The first gage gives the head on crest of weir, and the two located the mill give the head on wheels. The quantity flowing through wheels is added to the flow over the dam to give the total flow of creek. The dam is of earth, with plank facing, and there is li leakage. For a cross section of this dam see Mr. Rafter's paper "Flow of water over dams." The profile of the crest of the dam is so what irregular, and in order to facilitate computation has been divi into nine parts. Each part is assumed to have a horizontal crest li

flow over each part has been computed separately for various .s and a curve drawn showing the relation of the total quantity ing over the dam to various gage heights. From this curve the ı quantity for each head can be read off at once without making parate computation for each part of the dam. The flow over sec- s *A* to *E*, inclusive, in this dam was computed by using the coeffi- ts determined by Bazin's experiments of 1895, series No. 175, ı $q=8.025mLH^{\frac{3}{2}}$. The flow over sections *F* and *G*, which is over ıboards, was computed from Francis's formula for sharp-crested s, with $q=3.33LH^{\frac{3}{2}}$. In the mill there are two 27-inch Hercules ›ines, and records are made of the head on wheels and the open- of the gates twice each day. These turbines were rated by the yoke Power Company, so that by noting the head and the gate nings the quantity of water passing through the wheels can be puted.

nated daily discharge, in second-feet, of Sauquoit Creek at New York Mills, New York, for 1899.

[Drainage area, 52 square miles.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	42	12	17	18	0	53	19
2	34	.....	11	5	29	42	13
3	18	27	43	0	24	21	23
4	30	10	30	0	21	26	32
5	42	30	12	33	15	29	22
6	56	27	0	32	16	32	26
7	48	18	26	6	8	32	26
8	39	16	25	21	13	24	19
9	23	25	22	12	18	24	12
10	34	31	0	0	18	19	14
11	31	30	25	22	18	29	16
12	28	27	14	19	18	29	72
13	20	19	0	19	16	29	64
14	19	22	25	8	7	24	38
15	30	13	22	5	13	24	32
16	34	30	18	15	18	21	35
17	38	23	5	0	15	24	35
18	34	27	18	19	16	21	38
19	30	27	5	19	18	24	32
20	30	19	0	13	14	26	42
21	23	11	22	14	12	26	54
22	21	3	19	21	18	26	35
23	25	0	16	10	24	25	32
24	23	27	5	0	18	21	30
25	24	30	15	22	22	18	25
26	26	22	10	15	19	22	32
27	20	27	0	22	15	24	28
28	19	11	22	13	7	24	16
29	20	14	30	18	19	21	19
30	21	0	18	10	32	21	13
31	.....	27	5	.....	26	.....	14
Mean	29	20	15	14	17	26	29

WEST CANADA CREEK AT MIDDLEVILLE, NEW YORK.

his creek rises in the southwestern part of Hamilton County, New 'k, and flows in a southwesterly direction through Herkimer ınty, emptying into Mohawk River. It has considerable fall ›ughout its length, with chances of water-power development. asurements of flow have been made at Middleville, at the dam of Nelson Knitting Company. The drainage area of West Canada

Creek at this point is 519 square miles. There is a gage located just above the dam which gives the depth of water on crest; also a gage in the headrace and one in the tailrace of the Nelson Knitting Mill. There are also gages in the tailraces of the gristmill and planing mill located below on the same headrace. By these gages the flow is determined over the dam, through the wheels of the Nelson Knitting Company's mill, and at the gristmill and planing mill. The dam is of timber, with very little leakage. In the Nelson Knitting Mill is one 66-inch standard Leffel turbine, in the planing mill one 24-inch Rochester turbine, in the sawmill one 28-inch Chase turbine, and in the gristmill one 36-inch Camden turbine. Observations of the height and amount of gate opening of these wheels are made twice a day by E. J. Nelson. Near the center of the dam there is an ice slide 56 feet in length. The profile of the crest is nearly horizontal except at the ice slide. The flow over this dam is computed from Bazin's experiments of December, 1895, series No. 170. The experimental section of weir corresponding to the Rexford Flats dam agrees more closely to the form of the Middleville dam than the experimental weir used by Bazin. A revised discharge curve has been drawn, using the coefficients as found in the Cornell University experiment No. 15, corresponding to the Rexford Flats dam. For a cross section of this dam see Mr. Rafter's paper "On flow of water over dams."[1]

Estimated daily discharge in second-feet of West Canada Creek at Middleville, New York, for 1899.

[Drainage area 519 square miles.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1,114	198	273	257	480	1,281	330
2	763	140	292	191	510	2,867	580
3	593	200	345	145	470	1,744	710
4	550	116	316	145	436	1,199	710
5	531	240	237	210	337	1,040	518
6	480	240	155	205	253	831	540
7	294	256	286	195	288	469	1,750
8	314	204	262	219	190	542	1,670
9	258	675	256	169	232	482	840
10	182	293	242	145	220	390	700
11	130	807	246	188	234	420	640
12	283	443	214	201	210	410	3,150
13	297	445	125	221	239	342	4,710
14	248	343	254	205	219	313	2,530
15	753	236	246	204	140	372	740
16	839	430	253	189	241	343	840
17	499	600	239	145	238	363	640
18	320	560	235	197	235	372	1,060
19	339	479	174	208	217	220	1,880
20	331	345	110	213	152	337	3,520
21	373	327	226	239	261	310	2,530
22	346	225	245	238	190	363	1,400
23	263	140	257	204	245	293	990
24	293	241	229	145	225	273	1,150
25	155	241	254	209	238	273	900
26	283	241	183	476	231	249	840
27	273	244	110	433	267	312	580
28	280	239	255	248	224	292	540
29	308	171	247	213	965	310	640
30	275	115	262	386	1,040	310	540
31	.....	234	269	.....	629	.....	860
Mean	397	324	235	221	324	577	1,259

[1] Proc. Am. Soc. Civ. Eng., March, 1900, Vol. XXVI, No. 3, p. 315.

MOHAWK RIVER AT LITTLE FALLS, NEW YORK.

.e second point of measurement of Mohawk River was at Little ı, where the drainage area of the Mohawk River is 1,306 square ı. There is at this point a stone dam which furnishes power for ıstronga Knitting Mill and the Little Falls Paper Company's mill. gage in the headrace of the Astronga Knitting Mill gives the ıt on the crest of the dam and with the gage in the tailrace gives head on the wheels. These two gages are read by J. J. Gil-

There is a gage in the headrace and one in the tailrace of the e Falls Paper Company's mill, giving the head on the wheels. ırd of these gages is kept by William Hoffman. The dam varies ıwhat in section from one side of the river to the other. The ; of the dam is horizontal and is divided into two parts to facil- computation, on account of the variation in sections. The flow section *A* was computed from Bazin's experiments of July, 1887, 117; and that over section *B*, from Bazin's experiments of June, , series No. 135. A revised discharge curve was later used, based ı Cornell experiments Nos. 16 and 17. In the Astronga Knitting there is installed one 43-inch and one 54-inch T. H. Risdon & Co.'s ine; and in the Little Falls Paper Company's mill one 60-inch Cam- one 36-inch Camden, and one 42-inch Camden, also one 60-inch el built by M. Reddy. Records are kept of the flow through all hese wheels whenever running.

nated daily discharge, in second-feet, of Mohawk River at Little Falls, New York, for 1899.

[Drainage area, 1,306 square miles.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1,957	569	506	278	704	2,829	1,425
2	1,610	493	506	271	651	6,600	1,130
3	1,321	359	135	30	651	4,738	1,950
4	1,075	424	136	396	491	3,081	1,475
5	1,466	490	166	545	534	3,262	1,425
6	1,216	663	0	382	399	2,847	1,000
7	1,016	627	133	272	240	1,908	800
8	1,062	651	131	275	160	1,718	920
9	962	1,660	131	211	357	1,628	1,050
10	764	2,593	130	7	297	1,451	7,000
11	1,176	1,800	316	273	274	717	2,075
12	660	1,320	383	270	305	1,112	5,950
13	660	1,222	0	270	274	1,526	10,300
14	685	941	329	211	258	1,448	7,750
15	960	884	352	230	196	1,150	6,650
16	1,860	643	351	184	354	1,069	2,875
17	1,800	1,315	244	55	339	1,120	1,280
18	965	1,211	251	278	344	1,037	1,000
19	568	1,086	216	267	339	984	4,130
20	1,010	1,008	65	281	355	1,070	7,850
21	1,105	767	158	220	331	1,120	6,500
22	985	95	223	249	142	1,145	5,120
23	866	363	235	129	350	1,066	4,450
24	745	496	203	55	401	987	1,575
25	851	496	203	238	392	900	1,525
26	759	516	246	225	369	829	1,175
27	634	496	136	556	387	822	875
28	585	510	348	920	314	969	950
29	560	460	188	642	1,398	969	700
30	535	50	219	723	2,293	886	450
31	.....	697	277	.....	1,882	.....	380
Mean	1,014	803	223	298	509	1,700	2,959

EAST CANADA CREEK AT DOLGEVILLE, NEW YORK.

This creek rises in Hamilton County, New York, and flows in a southerly direction between Fulton and Herkimer counties into Mohawk River. Observations are taken on this creek at Dolgeville, about 7 miles from its junction with the Mohawk, reached from Little Falls by a branch of the New York Central Railroad. The station is located at the stone dam, which furnishes power for the Dolgeville Electric Light Company. The dam is about 19 feet high, of solid stone masonry, and the water impounded is conducted from the dam to the power house, a distance of about 500 feet, through a wrought-iron flume 10 feet in diameter. A gage located on the abutment of the dam and one in the tailrace of the power house are read twice each day by Henry Meyer, who is employed in the power house. The crest of the dam is horizontal, and flow over it is computed from Bazin's experiments of July, 1887, series No. 117. Experiments known as No. 13 were carried on at Cornell University to determine coefficients of flow over a weir of similar form. In the power house there are installed three Smith-Vaile Victor wheels; two of them 36 inch and one 15 inch. Records are kept of the daily head on these wheels and the amount of gate openings.

Estimated daily discharge in second-feet of East Canada Creek at Dolgeville, New York, for 1899.

[Drainage area 256 square miles.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	390	145	165	108	70	1,000	175
2	320	100	225	178	165	1,560	310
3	240	148	240	178	150	840	330
4	.....	94	180	99	150	710	400
5	.....	150	135	128	145	480	310
6	.....	150	99	118	140	520	260
7	220	170	165	113	140	410	190
8	260	230	160	108	130	380	190
9	220	309	160	75	120	360	190
10	220	383	160	108	140	340	200
11	238	283	170	108	130	310	230
12	220	213	180	120	125	110	1,850
13	220	213	50	108	120	230	2,820
14	230	213	40	108	120	260	1,420
15	280	195	20	108	150	260	1,040
16	270	294	125	108	120	310	880
17	192	380	30	108	125	230	710
18	154	280	125	108	160	260	1,240
19	180	210	40	108	150	150	1,590
20	200	170	40	125	155	260	610
21	300	165	120	125	150	240	1,330
22	230	135	120	120	115	220	840
23	210	99	120	120	125	220	740
24	162	145	130	120	150	220	490
25	134	165	140	120	145	190	390
26	190	175	120	225	145	180	240
27	190	160	40	225	140	180	360
28	180	175	120	180	140	180	310
29	160	165	120	170	300	180	310
30	160	.....	120	190	380	180	280
31	.....	155	120	.....	262	.....	160
Mean	221	196	122	127	153	367	658

GAROGA CREEK AT FORT PLAIN, NEW YORK.

This stream rises in Fulton County, New York, and flows in a southesterly direction into Mohawk River. Observations for the compuon of flow have been taken at Levi Yoran's mill, at Fort Plain. The am here located is of wood and fairly tight. Gages were read above ie dam, giving the height on crest, and in the tailrace of the mill. he water is conducted from the creek above the dam through the ill by a 4-foot circular flume laid underground. The flow over this am is computed from Bazin's experiments of July, 1894, series No. 30, with $q=8.025mLH^{\frac{3}{2}}$. Experiments were afterwards conducted t Cornell University, from which new coefficients were determined nd a revised discharge curve plotted. In the mill there is installed ne 28-inch and one 11-inch Lesner turbine, made at Fultonville, New York. These wheels were seldom used, but when they were run careful records were kept of the head and gate openings, so that the quantity passing through the wheels added to the flow over the dam would give the total flow of the creek. On May 30, 1899, observations at this station were discontinued.

CAYADUTTA CREEK AT JOHNSTOWN, NEW YORK.

This creek rises in Fulton County, New York, and flows in a southerly direction into Mohawk River near Fonda. Observations are made at the dam of the Johnstown Electric Light and Power Company, 1 mile below Johnstown, the record being kept by E. Shook, superintendent. The dam is 33 feet high, is built of timber, and has very little leakage. The impounded water is carried from above the dam to the wheelhouse through a 5-foot circular wooden flume. Gages are read above the dam, giving the height on crest, and in the tailrace, which show the head on wheels. The profile of the crest is somewhat irregular, and to facilitate computation has been divided into four parts, the crest lines of each part being assumed horizontal. The flow over section *C*, which is the regular spillway, is computed from Bazin's experiments of July, 1894, series No. 130, with $q=8.025mLH^{\frac{3}{2}}$. The flow over sections *A*, *B*, and *D*, which are the bulkheads, is computed from Bazin's experiments of July, 1887, series No. 115. Experiments upon sections which are considered to correspond more closely with the conditions at Johnstown were carried on at Cornell University, and a revised discharge curve derived, using the coefficients determined by the Cornell experiments. In the computation for the revised discharge curve the coefficients derived from experiment No. 12, corresponding to Bazin's experiment No. 115, were used for sections *A*, *B*, and *D*; and those determined by experiment No. 2, corresponding to Bazin's series No. 135, were used for section *C*.

For a cross section of this dam see Mr. Rafter's paper "On flow of water over dams."[1]

Estimated daily discharge in second-feet of Cayadutta Creek at Johnstown, New York, for 1899.

[Drainage area, 49 square miles.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	30	21	20	16	12	33	19
2	28	15	22	20	24	31	.....
3	29	24	32	12	24	28	14
4	17	17	22	19	25	48	37
5	29	20	21	28	17	34	27
6	28	30	11	16	15	26	23
7	18	19	19	23	19	28	23
8	30	34	20	22	9	26	23
9	21	16	20	17	18	22	23
10	19	27	20	7	20	27	13
11	18	25	17	16	24	36	27
12	30	18	23	19	23	20	238
13	25	18	8	20	13	28	207
14	24	16	20	17	20	28	145
15	25	18	20	19	17	30	55
16	25	13	20	20	24	20	40
17	25	23	20	11	26	21	44
18	17	25	20	19	33	20	36
19	25	26	19	20	21	6	51
20	37	20	9	21	(a)	27	85
21	32	19	15	20	(a)	27	62
22	33	23	16	17	(a)	26	42
23	32	8	14	19	(a)	25	26
24	32	18	16	14	21	24	19
25	18	22	16	20	18	26	56
26	29	19	14	32	18	14	60
27	26	16	11	36	19	30	25
28	30	17	15	26	16	28	24
29	30	17	16	27	30	28	20
30	22	14	16	26	30	15	19
31	.....	25	16	.....	.....	.....	11
Mean	26	20	18	20	21	26	49

a Repairing dam; water drawn off October 20 to 23.

SCHOHARIE CREEK AT FORT HUNTER, NEW YORK.

Schoharie Creek rises in Green County, New York, and flows in a northerly direction through Schoharie and Montgomery counties, and empties into Mohawk River near Tribes Hill Station. Observations for the computation of flow are made on this creek at the State dam, which impounds water for the feeder of the Erie Canal at Fort Hunter. The dam is of timber and practically free from leakage. The profile of the crest of the dam is somewhat irregular, and to facilitate computation is divided into six parts, each part being assumed horizontal. The value of the coefficients of flow over this dam has been obtained by taking the mean of the coefficients for series Nos. 117 and 141 of Bazin's experiments. Cornell experiments No. 114, performed upon the section corresponding to the Rexford Flats dam, was considered to conform more closely to the conditions at Fort Hunter than the sections used by Bazin, and a revised discharge curve was drawn,

[1] Proc. Am. Soc. Civ. Eng., March, 1900, Vol. XXVI, No. 3, p. 316.

g the Cornell coefficients.[1] A measurement of Schoharie Creek made near the village of Schoharie, New York, by students of the mer School of Surveying of the Massachusetts Institute of Techgy in June, 1889, under the direction of Prof. George F. Swain. surement was made by means of a Fteley meter. The results ved a discharge of 972 second-feet.

nated daily discharge in second-feet of Schoharie Creek at Fort Hunter, New York, for 1899.

[Drainage area 947 square miles.]

Day.	June.	July. a	Aug. a	Sept. a	Oct.	Nov.	Dec.
1	495				4,147	1,215	661
2	495				2,247	1,895	661
3	595				2,047	1,795	711
4	595				2,527	1,215	761
5	495				2,747	1,215	841
6	495				2,247	1,045	841
7	495				2,047	1,215	786
8	425				1,827	1,215	786
9	405				2,047	1,065	841
10	395				1,247	1,045	786
11	395				1,247	1,215	841
12	395				1,827	1,895	786
13	395				1,827	2,115	881
14	395				2,247	1,795	961
15	395				1,827	1,795	1,111
16	395				2,527	1,215	1,181
17	395				1,247	1,215	1,051
18	395				1,077	1,045	1,111
19	395				867	1,045	1,261
20	395				1,247	1,045	1,111
21	395				1,077	915	1,261
22	395				867	915	1,261
23	395				1,247	735	1,261
24	395				1,077	735	1,111
25	395				2,247	795	1,051
26	395				2,047	735	1,051
27	395				2,427	705	961
28	395				1,827	615	961
29	395				2,247	615	1,261
30	395				2,427	575	1,261
31					1,827		1,261
Mean	413				1,880	1,155	989

a Data not sufficient to compute record for July, August, and September

MOHAWK RIVER AT SCHENECTADY, NEW YORK.

few measurements of the flow of Mohawk River have been made 'reeman's toll bridge, about one-fourth of a mile above the Dela- and Hudson Canal Company's railroad bridge and about 1 mile w the New York Central and Hudson River Railroad bridge. A porary station was established here on January 28, 1899, and ntained until September 30, 1899, by Prof. Elton D. Walker, of on College, Schenectady, New York. The observer is Mrs. J. gin. The equipment consists of a wire gage with a 4-pound iron weight and galvanized line. The graduated rod is fastened to guard rail on the upstream side of the northwest section of the

[1] flow of water over dams, by George W. Rafter: Proc. Am. Soc. Civ. Eng., March, 1900, XVI, No. 3, p. 317.

bridge and is marked in tenths of a foot from zero to 17 feet. There is a bench mark on the upstream end of the top of the capstone on the pier nearest the northwest or right bank of the river. A second bench mark is the southerly corner of the top of the masonry bridge seat on the upstream end of the northwest abutment. Both bench marks are 23.96 feet above the zero of the gage. The initial point for soundings is the face of the bridge seat on the upstream end of the southeast abutment. The channel is approximately straight and of uniform width for 600 feet above and half a mile below the site. The section is obstructed by three piers and crib foundations, but is otherwise good. The swiftest current is through the southeast span. The right bank is low and liable to overflow, but the road running to the northwest prevents the overflow passing around the bridge except in unusually high freshets. The left bank is high, being the tow-path of the Erie Canal, and is not liable to overflow except in extremely high freshets occurring at the time of an ice jam in the river below. Measurements are made from the upstream side of the bridge. The three following discharge measurements were made during 1899 by Prof. E. D. Walker: April 3, gage height 7.18 feet, discharge 5,298 second-feet; May 26, gage height 6.22 feet, discharge 2,092 second-feet; June 30, gage height 5.38 feet, discharge 482 second-feet.

Daily gage height in feet of Mohawk River at Schenectady, New York, for 1899.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	6.60	8.15	7.45	8.60	(a)	5.33	5.20	5.10
2	6.30	8.05	7.60	8.45	(a)	5.30	5.18	5.17
3	6.10	7.50	7.40	8.75	(a)	5.30	5.35	5.15
4	6.10	7.20	7.10	7.95	(a)	5.30	5.35	5.17
5	6.10	8.00	7.80	7.40	(a)	5.23	5.40	5.20
6	6.70	13.80	8.43	7.00	(a)	5.23	5.38	5.18
7	6.10	10.93	9.53	6.70	(a)	5.22	5.20	5.15
8	6.10	9.00	10.15	6.55	5.50	5.30	5.20	5.20
9	6.20	8.80	11.13	6.45	5.45	5.33	5.15	5.20
10	6.30	8.20	9.80	6.25	5.43	5.78	5.15	5.12
11	6.10	7.85	9.30	6.20	5.40	6.10	5.15	5.10
12	5.90	7.65	10.90	6.20	5.38	5.98	5.18	5.10
13	5.90	11.84	11.80	6.45	5.30	5.70	5.20	5.08
14	5.90	10.15	12.93	6.50	5.28	5.50	5.20	5.05
15	5.95	9.40	13.50	6.60	5.33	5.48	5.15	5.05
16	6.00	8.70	12.88	6.55	5.30	5.45	5.12	5.05
17	6.00	8.60	11.55	6.40	5.70	5.40	5.10	5.00
18	6.00	7.70	11.25	6.58	5.72	5.70	5.12	5.03
19	6.00	7.30	11.20	6.80	5.53	5.68	5.05	5.00
20	6.15	8.40	11.50	6.98	5.43	5.55	5.12	5.10
21	6.30	8.50	11.55	7.35	5.45	5.45	5.10	5.10
22	6.85	7.90	11.10	7.25	5.90	5.45	5.08	5.10
23	8.85	7.65	10.70	6.95	5.55	5.30	5.05	5.10
24	8.84	7.75	10.60	6.58	5.45	5.25	5.10	5.10
25	8.00	7.95	10.60	6.35	5.40	5.23	5.10	5.08
26	7.70	7.70	10.45	6.22	5.40	5.20	5.08	6.53
27	7.35	7.80	10.40	6.10	5.38	5.20	5.10	8.05
28	8.10	7.25	10.00	6.05	5.33	5.20	5.12	6.35
29	.....	7.10	9.45	6.20	5.38	5.20	5.05	5.90
30	.....	7.75	8.85	6.70	5.35	5.32	5.10	5.75
31	.....	7.23	.....	7.00	.....	5.15	5.10	(b)

a Repairing bridge. b Discontinued September 30.

MOHAWK RIVER AT REXFORD FLATS, NEW YORK.

›rvations of river height are made at Rexford Flats, 4 miles Schenectady, for the computation of flow of Mohawk River. › a State dam, built of solid masonry, with a timber apron, and hes water for the feeder of the Erie Canal. Gages are read ıg the height on crest of the dam and the head on the feeder o that the amount of water flowing over the dam into the feeder determined. The profile of the crest of the dam is irregular, facilitate computation has been divided into five sections. The of the coefficients for any depth on the crest of this dam has btained by taking the mean of the corresponding coefficients for Nos. 117 and 141 of Bazin's experiments. Experiments were l on at Cornell University to determine the coefficients of flow n experimental weir of the exact form of the one located at Rex-'lats. This was known as "Cornell experiment No. 14." A l discharge curve was computed, using the coefficients as deter- by these experiments. H. R. Betts is the observer at this ı. In comparing the results obtained at Little Falls and Rex-'lats, Mr. Robert E. Horton, who has made the computations, that he has not been able to reconcile them, the former appearing the more accurate and the latter too small in proportion. For › section of this dam see the paper "On flow of water over dams," orge W. Rafter: Proc. Am. Soc. Civ. Eng., March, 1900, p. 312.

'ischarge in second-feet of Mohawk River at Rexford Flats, New York, for 1899.

[Drainage area, 3,385 square miles.]

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2,288	928	328	228	2,728	1,368	1,328
2	2,288	928	328	228	2,928	1,368	1,328
3	2,078	679	438	228	2,928	2,928	3,208
4	2,078	608	438	228	2,628	5,028	2,448
5	2,078	608	528	228	2,628	6,528	2,628
6	1,538	608	608	228	2,628	6,528	2,908
7	1,538	438	328	228	2,478	8,628	3,578
8	1,538	438	278	228	2,328	9,028	4,548
9	1,378	608	278	228	2,178	7,928	6,078
10	1,378	528	278	228	1,428	4,828	8,328
11	1,128	438	278	228	728	2,778	8,958
12	1,128	438	278	228	728	2,178	10,028
13	928	378	278	228	728	1,578	10,828
14	928	328	278	228	728	1,928	15,828
15	1,038	328	278	238	1,228	2,078	21,358
16	1,038	328	278	278	1,578	1,578	24,228
17	2,928	758	278	278	1,828	1,368	19,128
18	3,528	928	278	278	1,928	1,368	13,128
19	4,628	678	278	278	1,428	1,128	8,128
20	5,128	678	228	278	1,348	1,128	10,228
21	2,628	438	228	278	1,348	1,228	6,328
22	3,228	328	228	278	1,348	1,478	4,928
23	2,168	328	228	278	1,228	1,578	4,578
24	2,168	308	228	278	1,148	1,578	4,578
25	2,078	288	228	278	1,128	1,468	2,428
26	1,538	288	278	3,228	1,028	1,368	2,928
27	1,538	328	278	9,178	828	1,128	2,928
28	1,538	438	238	6,328	728	1,128	2,828
29	1,428	328	208	1,678	1,228	1,128	2,628
30	1,538	378	208	2,778	1,348	1,368	2,428
31	.....	338	208	.....	1,348	.....	2,228
Mean	2,014	498	294	980	1,608	2,824	7,001

SCHROON RIVER AT WARRENSBURG, NEW YORK.

This river rises in Essex County, along the southern slopes of the highest mountains in the Atlantic group, and flows in a general southerly direction for about 45 miles, until it joins Hudson River, as described in Water-Supply Paper No. 24, page 43. There are no developed water powers excepting that at Warrensburg, near the mouth. At this point records of river height have been kept by J. Goodfellow, the superintendent of the Schroon River Pulp Company, The dam at this point was built in 1893, and is said to be as tight as any of its kind. The observations were begun in 1895, the gages being established by Mr. George W. Rafter in connection with his investigations of the Upper Hudson storage surveys, in progress at that time. Mr. Wallace Greenalch, as assistant to Mr. Rafter, computed the flow of the river, but in his opinion these computations were to a certain extent vitiated by the possible leakage through the dam and complications introduced by flashboards being continually changed.

HUDSON RIVER AT FORT EDWARD, NEW YORK.

This river, as a whole, has been described in Water-Supply Papers Nos. 24 and 25. Estimates of flow have been made at two points, the upper at Fort Edward, about halfway between the mouth of Schroon River and Albany, and the lower at Mechanicville, above the mouth of Mohawk River. Records are being kept of the height of water surface above the crest of the dam at Fort Edward by the International Paper Company, B. A. Carr, superintendent. The estimated discharge was computed at the office of the State engineer and surveyor, but without taking the modifications introduced by the flashboards into account. The data were later placed in the hands of Mr. Robert E. Horton, but he has had opportunity to compute the flow during only one or two months. There is a peculiarity in regard to the method of reading the gage, but otherwise the results are satisfactory and worthy of computation.

HUDSON RIVER AT MECHANICVILLE, NEW YORK.

A daily record of the height of water passing over the dam of the Duncan Company, at Mechanicville, New York, has been kept, with few omissions, since 1887, as described in the report prepared by George W. Rafter.[1] These observations are made twice daily, at 7 a. m. and at 4 p. m., except Sundays, when the afternoon observations are omitted. The depth of the water on the crest of the dam is measured at a point sufficiently removed from the crest not to be influenced by the curve of the water surface. Besides these readings,

[1] Water-Supply and Irrigation Paper No. 24, page 78.

the difference in elevation between the surface of the water at the entrance and discharge from the water wheels is noted. The flow, as stated by R. P. Bloss, the engineer of the Duncan Company, is obtained by the use of Francis's formula for weirs with wide crests: $q=3\ LH^{\frac{3}{2}}$, in which q is the discharge in cubic feet per second, H the head in feet on crest of the dam, and L the length of the dam, which, in this case, is 794 feet. The coefficient used (3) was determined for dam of similar cross section. When the water wheels are in operation the head on wheels is determined by observation, and the amount of water used on each wheel under the given head is taken directly from the table given by the water-wheel builder. There being no leakage of the dam or canal the sum of the flow over the dam and the flow through the wheels gives the total flow of the river at the time of the observation.

Daily discharge in second-feet of Hudson River at Mechanicville, New York.

[Drainage area, 4,500 square miles.]

1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	24,147	3,177	22,189	21,647	9,050	6,627	2,324	2,374	2,077	2,991	3,484	13,028
2	22,847	3,289	32,900	20,147	7,252	6,627	2,324	2,736	1,770	3,441	3,652	11,650
3	19,547	3,402	27,525	18,947	7,027	6,627	2,234	3,099	1,770	3,916	3,332	8,200
4	15,627	3,402	25,880	16,097	6,802	4,752	2,324	2,949	1,770	4,016	3,332	7,290
5	11,652	3,527	20,230	14,774	6,202	4,477	2,324	2,674	1,770	4,116	3,652	7,450
6	7,677	3,477	18,122	13,452	6,202	4,477	2,324	2,324	3,055	3,841	23,335	7,575
7	5,677	13,327	17,247	14,327	5,677	4,389	2,999	2,324	4,341	3,666	25,735	7,700
8	5,602	7,427	16,822	13,127	5,402	4,302	2,724	2,324	3,316	3,916	24,235	6,853
9	5,677	6,302	16,397	13,127	4,902	5,277	2,799	2,412	2,916	3,916	22,735	7,850
10	5,602	5,177	14,247	13,677	5,002	6,227	2,774	2,499	2,791	3,441	19,085	11,493
11	5,377	5,177	11,837	13,827	5,102	8,127	2,774	2,449	2,616	3,678	16,985	10,922
12	5,139	4,377	8,502	15,708	4,477	7,927	2,624	2,399	2,541	3,916	15,735	10,067
13	4,902	4,202	7,327	17,589	4,527	6,027	2,474	2,424	2,441	3,391	14,135	9,259
14	4,902	4,027	7,127	25,314	3,802	6,127	2,624	2,399	2,341	3,791	12,680	8,450
15	4,702	4,377	6,789	34,414	3,602	6,227	2,324	2,374	2,491	7,416	11,582	7,950
16	4,302	3,864	6,452	39,775	3,877	5,677	2,324	2,384	2,491	6,766	10,485	6,253
17	4,152	3,352	6,027	48,300	3,877	6,127	2,324	2,394	2,291	5,741	10,680	9,125
18	3,877	3,677	5,602	55,400	3,877	4,677	2,324	2,424	2,241	5,278	9,635	6,750
19	4,127	4,077	5,677	59,393	3,352	4,152	2,324	2,499	2,266	4,816	8,380	5,350
20	4,377	4,152	15,702	52,050	3,227	4,077	2,324	2,474	3,503	4,366	7,635	5,138
21	4,152	3,752	11,977	45,400	3,227	4,139	2,949	2,394	4,741	4,016	6,965	4,925
22	4,027	3,677	10,077	37,436	2,977	4,202	4,324	2,374	4,691	4,541	7,025	4,300
23	3,952	3,739	8,177	32,314	2,952	3,177	5,349	2,361	4,116	4,166	7,085	4,400
24	3,677	3,802	6,102	26,230	3,052	3,002	4,774	2,349	3,716	4,166	6,585	3,435
25	3,802	3,952	6,302	21,672	3,152	2,777	3,424	2,374	3,666	4,141	6,385	3,918
26	3,877	3,802	7,877	18,349	2,977	2,677	3,074	2,324	2,991	4,116	9,185	4,400
27	3,952	3,677	13,997	15,027	3,152	2,427	2,724	2,324	2,991	3,116	10,485	4,350
28	3,527	3,677	9,177	12,102	3,527	2,489	2,449	2,324	2,991	2,916	11,535	4,300
29	3,277	11,477	12,787	10,077	3,802	2,552	2,349	2,324	2,791	3,116	12,110	3,675
30	3,177	.....	16,397	9,477	5,027	2,377	2,474	2,324	2,866	3,241	12,685	3,950
31	3,177	.....	20,147	.....	5,827	.....	2,374	2,324	.....	3,316	.....	4,300
Mean	6,791	4,668	13,600	24,972	4,610	4,738	2,772	2,442	2,879	4,106	11,352	6,913

Daily discharge in second-feet of Hudson River at Mechanicville, New York—Continued.

1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4,110	3,595	3,000	13,028	13,950	9,300	5,950	14,290	4,000	2,290	2,150	17,121
2	4,550	3,300	2,664	12,906	13,100	8,400	5,050	13,650	3,800	2,245	3,475	15,655
3	4,485	3,675	3,065	13,028	12,250	6,830	4,500	11,810	3,295	3,065	10,550	13,539
4	4,420	4,512	11,193	13,789	12,114	11,950	4,500	11,650	3,205	2,290	10,149	11,466
5	4,300	3,300	7,050	14,550	12,728	13,950	4,500	9,450	3,033	2,170	8,817	13,509
6	6,023	4,230	13,950	18,670	12,250	12,425	4,500	8,825	2,770	2,150	7,314	20,531
7	5,600	6,346	11,225	21,450	13,150	10,900	3,932	7,400	2,715	2,150	5,915	16,404
8	5,350	8,450	8,500	21,300	11,810	8,725	4,650	6,485	2,664	2,150	5,752	15,435
9	5,185	5,975	8,815	20,750	10,155	10,600	5,430	5,570	2,540	2,150	5,752	14,437
10	5,130	5,350	12,900	23,806	8,500	25,980	4,750	5,150	2,450	3,180	9,266	13,462
11	5,075	4,200	14,550	18,890	8,400	27,188	4,650	6,025	2,340	2,150	9,224	12,927
12	3,880	3,932	14,110	13,973	9,350	24,790	4,550	13,350	2,370	2,150	11,254	13,000
13	3,595	3,180	12,900	15,918	10,450	22,170	6,750	11,350	2,400	2,450	12,243	17,150
14	3,370	3,328	10,925	15,550	22,550	19,550	23,150	9,650	2,664	3,000	13,768	15,559
15	3,300	3,475	8,950	16,940	19,625	17,280	31,060	9,238	2,370	3,135	10,794	31,178
16	3,595	3,180	8,400	22,269	17,188	15,900	22,750	8,825	2,715	3,065	10,000	35,706
17	3,853	3,295	7,150	23,340	14,750	13,150	18,670	9,450	2,450	4,110	13,300	32,515
18	4,110	3,135	6,830	23,908	13,650	11,200	16,390	8,250	2,340	2,664	11,800	29,702
19	3,300	2,930	6,830	24,476	11,500	9,220	14,110	7,550	4,000	2,900	11,620	23,114
20	3,300	2,820	12,900	23,621	12,100	9,220	11,950	7,775	2,290	2,664	10,650	15,379
21	3,300	3,058	15,375	20,950	11,300	9,220	11,193	7,050	2,664	2,370	8,628	12,207
22	3,350	3,295	17,850	19,625	11,810	8,950	11,350	6,500	2,540	2,346	9,354	8,486
23	3,435	4,120	18,470	17,150	10,980	7,025	11,950	5,950	2,180	2,150	8,182	6,900
24	3,555	4,212	23,010	16,941	10,150	7,250	12,230	6,830	2,380	3,070	7,451	4,819
25	3,675	3,135	23,957	19,346	9,300	6,220	11,425	7,775	2,290	2,290	6,368	2,785
26	2,925	3,050	19,950	21,750	10,000	5,820	10,620	7,775	3,930	2,150	7,395	2,296
27	2,875	3,000	17,973	25,200	10,330	5,485	9,450	6,750	2,664	2,150	15,402	4,122
28	3,350	3,000	15,912	22,450	11,650	5,150	8,950	6,025	2,770	2,150	15,848	7,047
29	3,530	.....	13,850	19,017	10,950	4,400	19,550	5,513	2,370	2,150	19,456	6,467
30	3,530	.....	13,028	17,625	10,700	7,400	20,950	5,000	2,380	2,150	16,984	6,467
31	3,563	.....	13,350	.....	10,450	.....	14,930	4,550	.....	3,135	.....	6,467
Mean	4,007	3,895	12,214	19,074	12,167	11,855	11,109	8,241	2,756	2,524	9,995	14,382

1898.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5,512	5,235	5,295	20,306	13,474	9,490	3,179	3,005	a 4,345	3,222	7,954	6,300
2	4,689	5,095	5,280	18,018	11,545	8,159	3,014	3,888	a 4,007	2,877	7,667	6,130
3	5,035	5,272	5,208	15,810	9,762	7,558	3,007	6,225	a 4,145	2,835	6,590	5,698
4	5,186	4,151	5,208	13,890	10,820	6,292	3,007	5,722	a 4,340	2,780	6,500	5,185
5	5,306	4,353	5,055	11,932	10,570	5,808	3,364	6,031	4,547	11,210	5,890	5,994
6	5,485	6,475	5,200	10,692	11,300	5,508	2,588	5,832	4,145	20,089	5,803	6,500
7	6,626	5,203	5,250	9,928	11,032	4,729	2,453	5,415	4,007	9,472	5,890	6,322
8	7,256	5,000	5,186	8,787	10,250	4,399	2,314	5,091	4,930	8,261	5,503	5,456
9	5,890	4,826	6,819	8,158	9,709	4,249	2,220	4,335	4,217	7,872	5,872	4,150
10	6,168	4,826	7,431	7,924	8,695	3,978	1,163	3,926	3,813	6,960	6,238	4,675
11	5,951	6,325	10,361	7,915	7,875	3,425	2,000	3,743	3,368	6,038	20,256	4,345
12	5,298	10,022	20,994	7,646	8,420	3,857	2,182	3,387	3,304	6,109	16,262	4,290
13	11,499	13,042	27,300	8,553	11,054	4,299	2,058	3,331	3,188	5,331	14,510	3,739
14	10,975	10,425	39,389	9,815	10,585	4,945	2,080	3,148	2,732	4,829	13,202	3,540
15	10,160	9,074	36,375	9,824	10,161	7,662	2,184	3,362	2,597	6,888	11,385	3,850
16	10,647	8,100	32,325	12,188	9,967	6,872	2,159	3,250	2,487	7,838	10,366	4,007
17	9,672	5,682	30,625	12,575	10,082	5,681	1,163	3,223	2,597	8,125	9,722	4,495
18	7,515	7,480	32,325	12,188	10,637	4,620	2,192	3,235	2,873	7,250	8,910	4,590
19	7,008	7,788	29,935	11,155	9,404	4,851	2,224	3,660	2,873	6,500	8,922	4,590
20	7,952	7,571	30,000	11,157	9,412	5,593	2,175	4,507	3,365	6,508	10,505	4,885
21	13,757	8,009	36,235	10,922	8,355	4,603	2,192	4,495	2,975	6,418	11,167	5,035
22	10,170	7,906	34,035	10,127	7,954	4,399	3,188	4,718	2,899	6,310	10,366	5,035
23	9,780	7,258	30,615	9,815	8,000	4,198	3,565	3,927	2,666	6,894	9,610	6,908
24	11,458	6,542	27,450	9,627	8,400	4,348	3,549	5,779	3,297	7,578	8,898	8,369
25	9,436	6,263	24,860	20,440	9,491	4,097	3,928	a 11,167	5,231	7,178	8,685	7,747
26	8,628	5,992	21,860	24,210	11,953	4,024	4,565	a 9,953	6,878	6,693	7,847	6,885
27	7,788	5,294	19,600	24,338	14,758	4,115	4,258	a 8,125	5,706	9,382	6,413	5,872
28	7,719	5,911	19,910	20,440	15,327	3,556	3,656	a 8,250	4,775	11,042	5,820	4,618
29	6,624	.....	20,660	18,165	14,140	3,508	3,352	a 6,109	4,345	10,485	6,300	4,628
30	5,361	.....	23,560	14,873	12,727	3,238	3,175	a 4,829	3,650	10,059	6,300	4,828
31	4,860	.....	22,640	.....	10,490	.....	3,015	a 4,217	.....	9,953	.....	5,348
Mean	7,723	6,754	20,225	13,047	10,525	5,069	2,751	5,029	3,810	7,516	8,978	5,291

a Discharge August 25 to September 4, not exact, owing to irregular flashboards.

Daily discharge in second-feet of Hudson River at Mechanicville, New York—Continued.

1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4,262	3,910	7,847	7,980	26,900	3,990	2,220	1,520	1,713	.....	4,564	3,005
2	4,262	4,268	7,040	7,159	27,617	3,796	1,047	629	1,561	4,042	8,889	3,414
3	5,209	4,268	6,403	6,955	25,551	3,601	2,128	1,213	.....	3,453	12,020	3,753
4	6,065	4,150	.....	7,934	22,472	2,220	.....	1,153	1,293	2,850	11,899	5,545
5	9,146	4,002	.....	9,405	19,242	2,990	2,741	1,085	1,890	2,745	10,346	6,678
6	8,460	4,223	16,501	9,955	15,152	2,840	1,610	.....	1,764	2,650	11,049	5,974
7	8,355	4,048	12,266	11,719	12,662	2,728	1,670	1,494	1,706	2,571	9,308	5,210
8	8,350	4,275	9,077	19,708	10,960	2,805	1,211	1,616	1,680	.....	8,140	4,558
9	8,026	3,448	8,665	18,275	9,270	2,525	.....	1,475	1,466	2,596	7,106	3,806
10	6,562	3,605	7,909	15,062	8,587	2,290	3,006	484	.....	2,712	6,662	3,265
11	5,706	3,622	7,315	15,582	7,446	.....	3,533	1,148	1,480	2,903	6,182	3,569
12	5,250	4,062	11,730	16,875	7,550	2,399	3,296	993	1,598	2,874	5,490	4,979
13	5,272	4,196	15,437	17,145	7,155	2,505	3,245	.....	1,471	2,926	6,321	11,183
14	5,960	4,508	12,153	21,378	7,060	2,230	3,002	1,580	1,567	2,353	5,536	14,576
15	7,435	4,600	10,555	27,975	7,772	2,135	2,800	1,680	1,484	.....	5,179	14,979
16	8,910	4,798	10,012	29,730	7,346	3,078	.....	1,501	1,549	2,177	4,858	13,452
17	10,155	5,598	9,080	31,112	5,738	3,060	2,861	1,815	.....	2,132	5,283	9,646
18	9,685	5,691	7,895	29,667	5,729	2,762	3,338	979	711	1,853	4,857	9,534
19	7,339	5,620	9,322	29,711	5,928	2,950	2,860	1,320	1,636	1,798	4,359	9,968
20	6,385	5,267	11,350	33,940	5,917	2,508	2,560	.....	957	1,997	4,838	10,950
21	6,297	4,855	9,670	36,210	5,925	2,372	2,485	1,610	941	2,185	4,729	11,048
22	5,770	5,686	9,337	36,210	6,187	2,280	2,295	1,123	1,448	.....	4,587	10,721
23	5,697	10,083	8,645	37,146	5,313	2,105	.....	1,743	1,464	2,466	4,297	9,642
24	5,522	7,501	8,657	38,283	4,756	1,878	2,240	2,460	.....	2,698	3,964	8,068
25	6,950	5,583	8,095	39,064	4,710	304	2,253	1,383	1,516	2,372	3,731	8,241
26	5,775	5,255	7,492	41,475	4,462	1,878	2,188	1,463	2,116	2,304	3,472	7,821
27	5,438	6,450	6,895	40,064	4,117	2,241	2,021	.....	6,000	2,128	4,027	5,832
28	4,545	10,326	6,615	38,300	3,985	2,290	2,140	1,756	5,127	2,216	3,495	5,435
29	4,290	.....	7,835	33,908	4,125	2,368	1,686	1,738	4,413	.....	3,439	4,889
30	4,345	.....	8,765	30,292	3,787	2,512	.....	1,739	4,870	3,198	3,318	4,075
31	4,066	.....	7,602	.....	3,918	.....	2,055	1,477	.....	3,815	.....	2,585
Mean	6,437	5,141	9,316	24,607	9,591	2,539	2,402	1,417	2,054	2,616	6,066	7,303

SAWKILL RIVER NEAR KINGSTON, NEW YORK.

The Sawkill, a small stream which supplies Kingston, New York, with water, has been measured by Mr. William Rich Hutton, at a point about 4.5 miles above its mouth in Esopus Creek, its discharge being 1.25 second-feet. On two occasions after heavy rains the discharge at the same place has been more than 8,000 second-feet from a drainage area of 35 square miles. This quantity continued a very short time, probably about an hour. The location of this stream is shown on the Kaaterskill topographic sheet. It rises behind Overlook Mountain, flows by the village of Woodstock, and joins the Esopus about 4 miles below the city of Kingston. Reservoir No. 1 is shown on the map, but reservoir No. 2, constructed in 1897, about 1½ miles below Woodstock, is not given.

In April, 1895, the mountains being covered with snow 12 inches deep, there occurred a south wind and light rain for two days followed by twelve hours of very heavy rain. On the evening of April 4 the water in reservoir No. 1 began to rise rapidly, and about 9 p. m. the noise of the floating logs and ice and the rapidly rising water alarmed the gate keeper so that he moved his more important furniture by boat to higher ground. At midnight the water was at its highest and by 8 a. m. on April 5 it was falling rapidly. From the maximum height of water on the spillway it is computed that the outflow of the reservoir was a little less than 8,000 second-feet. In 1896 it is estimated that a similar flood furnished over 8,000 second-feet.

CROTON RIVER.

This stream receives its waters from the drainage area immediately north of the city of New York and east of Hudson River. It flows in a general southerly and westerly course, emptying into the Hudson above Sing Sing. A number of reservoirs have been built within its basin for the water supply of the city of New York, and a new dam is being constructed about 3.2 miles above the mouth, at what is known as the "Cornell site." The location of the river and principal reservoirs is shown on the West Point, Carmel, Tarrytown, and Stamford topographic sheets of the United States Geological Survey. Figures of the yield of this watershed have been prepared by the engineers of the aqueduct commission. The monthly discharges in second-feet for the years 1870 to 1898 have been printed in the Twentieth Annual Report, Part IV, page 83. The following table, obtained from Mr. W. R. Hill, chief engineer, gives a continuation of this for 1899. The figures of rainfall are those obtained at Boyds Corners, in Croton basin.

Rainfall and run-off of Croton River watershed for 1899.

[Drainage area, 338 square miles.]

Month.	Rainfall.	Run-off.	Month.	Rainfall.	Run-off.
	Inches.	*Sec.-feet.*		*Inches.*	*Sec.-feet.*
January	4.38	1,210	August	0.48	114
February	5.07	943	September	8.81	305
March	7.58	2,217	October	1.48	237
April	1.99	1,240	November	2.05	277
May	1.80	344	December	2.75	263
June	5.38	152			
July	5.99	344	The year	47.76	636

The total depth of run-off in inches during 1899 was 25.55, this being 53 per cent of the rainfall, as given in the above table.

DELAWARE RIVER AT LAMBERTVILLE, NEW JERSEY.

This river rises in Delaware County, New York, flows in a southerly direction, forming the boundary between the States of Pennsylvania and New Jersey, and empties into Delaware Bay. Measurements of flow were made in 1891 by Prof. Dwight Porter and students at the Delaware Water Gap, Pennsylvania. The results show a flow of from 2,000 to 2,200 second-feet during the latter half of June, 1891. This was said to be the lowest June stage for five years. Measurements were made during the drought of 1895 by Prof. L. M. Haupt at Point Pleasant, Pennsylvania, near the intake of the Delaware and Raritan Canal feeder. The discharge above the bridge was 1,657 second-feet and below the bridge 1,328 second-feet. Delaware River was measured by E. G. Paul, June 4, 1899, at Martins Creek, Pennsylvania, 7 miles above the mouth of Lehigh River, and a discharge

;,724 second-feet was found. Lehigh River was measured on June 899, by E. G. Paul, at the Glendon Bridge at Easton, Pennsylvania, was discharging 991 second-feet. Systematic measurements of r height were begun on July 23, 1897, at the covered toll bridge Lambertville, New Jersey, a town on the Belvidere division of Pennsylvania Railroad, 16 miles above Trenton. The gage, blished by E. G. Paul, consists of a stamped-link brass chain 33 t long, with a 6-pound sash weight attached. The chain passes r a pulley and the index is referred to a scale painted on a izontal board 32 feet long, fastened to the studding and inclosed a wooden cover. The zero of the gage chain is marked by a per rivet, which is 28.85 feet from the end of the weight, and ds 2 feet when the water is at zero on a gage on the first bridge r. Measurements are made from the windows of this covered dge. The initial point for soundings is on the left bank. The nnel above and below is nearly straight, the water being slug-h for a short space on the left side. The right bank is high d the bed of the stream is of gravel and sand. The observer is arles H. Naylor, collector of bridge tolls, Lambertville, New Jersey. cords of measurements may be found as follows: 1897, Nineteenth nual Report, Part IV, page 122; 1898, Twentieth Annual Report, rt IV, page 85. Three measurements were made during 1899, by E. Paul, as follows: March 31, gage height 6.30 feet, discharge 27,737 ond-feet; June 2, gage height 3.70 feet, discharge 6,410 second-t; September 19, gage height 2.75 feet, discharge 2,430 second-feet.

ily gage height, in feet, of Delaware River at Lambertville, New Jersey, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.95	(a)	6.80	6.25	4.75	3.60	4.40	4.20	3.45	4.65	3.40	3.80
2	(a)	(a)	6.80	6.25	4.60	3.60	4.30	4.00	3.35	4.45	3.80	3.80
3	(a)	(a)	6.30	5.95	4.60	3.30	3.95	4.00	3.35	4.25	4.05	3.80
4	(a)	(a)	6.25	5.80	4.50	3.20	3.75	3.90	3.30	4.10	4.65	3.80
5	5.40	4.50	7.95	5.65	4.40	3.05	3.65	3.85	3.45	4.05	4.75	3.95
6	6.05	4.45	8.30	5.70	4.30	2.90	3.65	3.70	4.90	3.95	4.60	3.85
7	7.00	4.40	9.65	5.90	4.20	2.95	3.65	3.90	4.35	3.90	4.55	3.90
8	6.55	4.40	8.20	7.40	4.10	2.85	3.60	3.65	3.95	3.85	4.35	3.75
9	6.10	(a)	7.20	9.10	4.00	2.90	3.90	3.55	3.85	3.75	3.75	3.75
10	5.80	(a)	6.45	8.70	3.90	2.90	3.80	3.45	3.75	3.70	4.10	3.85
11	5.35	(a)	6.20	7.65	3.85	2.85	3.75	3.65	3.50	3.60	4.10	3.70
12	5.00	(a)	6.30	7.15	4.00	2.70	3.70	3.55	3.90	3.60	4.10	3.75
13	4.80	(a)	7.50	7.75	4.00	2.60	3.75	3.35	3.65	3.60	4.25	4.20
14	4.90	(a)	9.15	8.45	4.00	2.65	3.55	3.15	3.45	3.50	4.50	5.30
15	5.05	(a)	8.10	8.85	3.90	2.60	3.55	3.10	3.35	3.50	4.45	5.60
16	5.40	(a)	7.70	9.00	3.80	2.60	3.45	2.95	3.15	3.40	4.35	5.30
17	5.95	(a)	6.90	8.90	3.80	2.50	3.60	2.80	3.10	3.40	4.35	5.10
18	6.10	(a)	6.45	7.85	3.70	2.60	3.60	2.75	2.85	3.45	4.50	4.85
19	5.50	(a)	7.40	7.25	3.80	2.45	3.70	2.50	2.75	3.40	4.50	4.70
20	5.30	7.60	8.70	7.05	3.90	2.40	3.75	2.80	3.90	3.40	4.45	4.65
21	5.30	6.65	9.00	7.15	3.90	2.40	3.55	2.65	3.90	3.40	4.30	4.75
22	4.95	5.70	8.05	7.00	3.80	2.45	3.50	2.75	3.90	3.45	4.20	4.75
23	5.05	6.05	7.70	6.70	3.70	2.75	3.35	2.90	3.75	3.35	4.20	4.65
24	4.95	5.95	7.35	6.15	3.60	3.00	3.25	2.85	3.70	3.30	4.20	5.10
25	7.30	5.65	7.25	5.95	3.60	3.25	3.10	2.60	3.65	3.25	4.10	5.45
26	6.00	5.45	7.00	5.70	3.50	3.70	3.15	2.75	5.40	3.20	4.00	5.45
27	5.60	8.25	6.65	5.50	3.40	4.30	3.40	3.95	6.05	3.20	4.00	5.20
28	5.25	7.20	6.60	5.40	3.40	4.05	4.15	4.20	6.25	3.20	3.95	5.00
29	4.95	.....	7.40	5.10	3.20	4.00	4.00	3.75	5.40	3.45	3.90	(a)
30	4.95	.....	6.80	4.90	3.20	4.00	3.85	3.55	5.00	3.25	3.90	(a)
31	4.75	.....	6.40	.....	3.40	.....	4.30	3.65	.....	3.20	.....	(a)

a Ice.

TOHICKON CREEK AT POINT PLEASANT, PENNSYLVANIA.

This stream drains an area of 102 square miles in the eastern portion of Pennsylvania and, flowing easterly, discharges into Delaware River about 8 miles above Lambertville, New Jersey. Measurements of the stream were begun in 1885 by Mr. Rudolph Hering, and continued by Mr. John E. Codman, hydrographer for the water department of the city of Philadelphia. The results by months from 1890 to 1898, inclusive, are given in the Twentieth Annual Report, Part IV, beginning on page 98. The following table gives the figures of daily flow for 1899:

Daily discharge in second-feet of Tohickon Creek at Point Pleasant, Pennsylvania, for 1899.

[Drainage area, 102.2 square miles.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	144	158	793	178	35	15	14	4	18	46	52	34
2	136	125	601	131	31	9	11	399	13	40	181	34
3	154	118	601	97	31	9	19	267	9	27	121	44
4	204	151	708	79	31	10	12	113	93	25	921	49
5	1,172	184	2,819	68	31	9	10	52	42	23	366	44
6	1,360	210	1,109	61	27	8	10	28	28	18	121	39
7	1,400	189	520	73	23	7	8	22	19	20	73	39
8	503	142	277	1,328	23	7	8	17	16	23	58	39
9	503	180	217	389	23	5	7	15	287	20	53	31
10	413	183	203	160	20	8	6	254	210	17	40	23
11	124	110	418	108	28	6	7	417	203	17	35	27
12	158	90	1,225	92	35	6	5	182	499	16	42	44
13	169	119	1,702	87	27	7	7	66	163	13	51	95
14	186	102	416	79	31	5	11	38	58	11	53	101
15	311	65	709	70	31	3	9	28	46	10	47	60
16	432	157	994	153	20	5	5	19	36	9	46	49
17	569	416	308	393	17	5	7	14	18	9	47	44
18	488	782	502	144	20	4	7	12	18	9	45	39
19	258	767	2,492	84	23	3	8	11	23	9	38	39
20	177	695	938	68	20	2	8	8	708	9	34	85
21	116	914	308	61	17	2	3	8	545	9	33	101
22	84	1,414	1,051	58	17	7	5	6	404	9	33	65
23	79	1,582	1,006	53	20	2	3	7	239	14	49	53
24	526	1,000	449	49	17	2	3	7	61	16	57	879
25	2,032	541	220	49	17	7	3	3	42	18	44	913
26	392	616	624	45	15	7	4	2	1,522	18	35	203
27	230	3,222	633	41	12	12	4	359	604	11	30	97
28	145	1,058	779	39	9	5	4	317	158	11	31	79
29	166	.....	1,307	39	12	17	6	62	78	10	36	65
30	169	.....	520	39	14	27	7	34	51	12	39	53
31	184	.....	239	.....	15	.....	4	27	.....	17	.....	49
Mean	419	546	797	144	22	7	7	90	27	17	94	113

NESHAMINY CREEK AT FORKS, PENNSYLVANIA.

The drainage basin of this creek is immediately south of that of Tohickon Creek. The waters of Big Neshaminy flow in a general easterly course, and after joining the Little Neshaminy continue southerly and empty into Delaware River about 12 miles above the city of Philadelphia. Measurements of the discharge of the stream have been made at the forks, where the drainage area is 139 square miles. The monthly discharges from 1890 to 1898 are given in the

wentieth Annual Report, Part IV, beginning on page 104. The fol-
wing table gives the daily discharge for 1899:

aily discharge in second-feet of Neshaminy Creek at Forks, Pennsylvania, for 1899.

[Drainage area, 139.3 square miles.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	527	213	611	349	67	31	15	27	15	36	144	54
2	453	213	569	280	73	31	13	248	15	31	154	51
3	97	213	540	243	67	27	9	2,162	28	31	162	48
4	71	213	686	221	61	19	10	104	41	27	1,257	57
5	405	173	3,687	201	53	17	14	43	32	22	252	54
6	2,105	119	913	176	50	17	13	23	19	38	145	48
7	1,298	97	573	255	47	13	10	15	15	59	107	41
8	306	97	377	1,047	45	13	13	15	15	53	85	41
9	277	105	388	362	46	15	14	14	13	36	81	36
10	213	97	343	245	38	19	14	488	43	27	81	36
11	213	80	510	204	64	19	13	2,577	78	22	81	36
12	213	72	959	186	89	17	10	151	80	19	85	36
13	213	72	1,318	176	73	17	10	71	68	19	85	65
14	228	72	407	166	53	15	10	48	23	22	77	80
15	203	72	1,172	159	48	15	8	36	15	19	72	60
16	189	89	813	193	48	15	8	27	15	19	68	45
17	457	319	242	301	43	15	9	22	15	22	68	36
18	252	553	722	177	54	15	9	19	13	123	68	31
19	145	574	2,490	149	68	15	8	19	41	113	56	36
20	115	974	742	139	57	15	6	17	430	57	51	57
21	105	1,373	382	129	36	15	6	14	166	41	48	72
22	105	1,373	1,765	115	36	15	6	79	138	32	41	57
23	100	1,402	976	105	44	15	6	19	65	27	77	41
24	1,117	849	405	105	51	13	6	19	41	27	147	792
25	1,927	446	414	105	47	11	6	19	41	22	90	401
26	333	809	490	105	36	13	11	13	578	22	74	125
27	242	3,950	417	101	31	13	23	11	204	22	72	89
28	213	815	1,398	92	31	13	27	13	89	17	63	72
29	213	.....	2,417	88	27	14	22	13	63	24	63	72
30	213	.....	588	73	22	15	325	14	48	17	63	63
31	213	.....	443	.....	27	.....	68	15	.....	24	.....	48
Mean	411	551	895	208	49	16	23	174	80	34	130	89

PERKIOMEN CREEK AT FREDERICK, PENNSYLVANIA.

The drainage area of this stream is immediately west of that of 'ohickon Creek. It flows in a general southerly course, emptying ıto Schuylkill River about 18 miles above Philadelphia. The point f measurement is at Frederick, about 12 miles above the mouth and bove two large tributaries, known as West Swamp Creek and North-ast Branch. The monthly discharges from 1890 to 1898, inclusive, re printed in the Twentieth Annual Report, Part IV, beginning on age 90.

The following tables give the daily flow from the time the gage was established to 1899:

Daily discharge in second-feet of Perkiomen Creek at Frederick, Pennsylvania.

[Drainage area, 192 square miles.]

1884.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	.....	.....	.....	.....	.....	100	44	155	93
2	.....	.....	.....	.....	.....	.....	.....	.....	79	58	59	64
3	.....	.....	.....	.....	.....	.....	.....	.....	71	58	57	64
4	.....	.....	.....	.....	.....	.....	.....	.....	63	61	71	79
5	.....	.....	.....	.....	.....	.....	.....	.....	60	58	342	78
6	.....	.....	.....	.....	.....	.....	.....	.....	55	46	140	828
7	.....	.....	.....	.....	.....	.....	.....	.....	53	48	91	3,425
8	.....	.....	.....	.....	.....	.....	.....	.....	50	41	70	380
9	.....	.....	.....	.....	.....	.....	.....	.....	46	41	50	230
10	.....	.....	.....	.....	.....	.....	.....	.....	44	41	48	179
11	.....	.....	.....	.....	.....	.....	.....	.....	38	37	47	187
12	.....	.....	.....	.....	.....	.....	.....	.....	39	40	62	981
13	.....	.....	.....	.....	.....	.....	.....	.....	38	36	69	600
14	.....	.....	.....	.....	.....	.....	.....	.....	33	36	75	256
15	.....	.....	.....	.....	.....	.....	.....	.....	35	25	75	2,409
16	.....	.....	.....	.....	.....	.....	.....	.....	37	25	73	516
17	.....	.....	.....	.....	.....	.....	.....	.....	37	25	52	232
18	.....	.....	.....	.....	.....	.....	.....	.....	37	20	48	236
19	.....	.....	.....	.....	.....	.....	.....	.....	38	16	48	186
20	.....	.....	.....	.....	.....	.....	.....	60	37	16	57	139
21	.....	.....	.....	.....	.....	.....	.....	58	37	21	76	106
22	.....	.....	.....	.....	.....	.....	.....	56	47	23	96	465
23	.....	.....	.....	.....	.....	.....	.....	56	47	48	93	449
24	.....	.....	.....	.....	.....	.....	.....	45	41	51	768	320
25	.....	.....	.....	.....	.....	.....	.....	47	37	43	223	247
26	.....	.....	.....	.....	.....	.....	.....	50	32	40	142	182
27	.....	.....	.....	.....	.....	.....	.....	54	28	41	121	171
28	.....	.....	.....	.....	.....	.....	.....	58	23	45	121	199
29	.....	.....	.....	.....	.....	.....	.....	89	29	87	262	241
30	.....	.....	.....	.....	.....	.....	.....	110	40	168	142	367
31	.....	.....	.....	.....	.....	.....	.....	130	.....	238	.....	1,239
Mean	.....	.....	.....	.....	.....	.....	.....	68	48	51	124	491

1885.

1	1,639	113	123	1,582	124	85	35	28	28	23	86	175
2	373	109	204	710	126	79	25	19	36	23	706	194
3	229	109	242	495	129	58	25	1,582	24	21	306	200
4	174	111	222	3,192	115	47	17	1,673	8	26	155	184
5	173	112	521	627	102	44	9	174	9	34	113	166
6	2,600	104	703	454	93	44	24	89	16	35	89	153
7	981	100	568	319	244	28	17	65	25	41	78	124
8	435	100	238	315	805	41	29	277	23	31	613	115
9	359	98	197	273	358	65	26	135	30	31	862	250
10	291	2,107	189	255	227	47	25	73	31	26	267	970
11	232	210	164	237	192	46	32	60	27	8	162	340
12	251	252	151	238	161	35	31	51	24	15	132	181
13	615	217	151	209	133	36	30	43	20	22	113	1,250
14	313	184	211	189	128	31	22	76	24	70	101	2,546
15	290	193	223	157	132	33	33	86	28	67	83	583
16	587	1,795	418	143	120	41	35	61	32	45	81	308
17	1,372	832	322	143	95	34	27	50	27	42	86	239
18	283	857	204	133	87	28	23	37	19	26	73	217
19	271	274	176	112	90	28	12	34	25	24	60	204
20	228	234	136	117	77	28	21	41	15	22	65	159
21	201	190	136	115	69	23	24	34	20	118	57	140
22	181	149	93	98	80	32	23	32	16	243	46	143
23	163	147	67	92	92	22	15	29	14	95	349	133
24	144	130	81	94	95	28	14	39	21	54	685	139
25	141	115	185	100	87	29	14	41	19	37	440	113
26	153	121	652	150	94	25	10	42	19	38	382	79
27	151	111	911	201	90	21	15	40	10	46	348	67
28	155	101	992	171	74	16	17	46	19	39	261	85
29	145	.....	538	139	62	18	26	35	17	39	206	100
30	120	.....	250	124	58	30	29	26	24	228	192	87
31	113	.....	985	.....	60	.....	17	28	.....	175	.....	292
Mean	431	327	331	373	142	37	23	16	22	56	240	321

Daily discharge in second-feet of Perkiomen Creek at Frederick, Pennsylvania—Continued.

1886.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	452	280	237	1,548	96	101	83	95	38	30	52	141
2	218	235	214	482	79	88	73	86	41	29	67	114
3	167	236	193	335	89	111	67	74	35	22	33	73
4	950	304	174	303	87	137	71	57	28	27	30	62
5	3,044	214	177	449	84	104	59	50	22	22	51	55
6	516	172	163	4,021	83	76	52	47	28	17	36	44
7	300	155	143	1,626	90	79	47	57	29	23	53	65
8	222	159	163	640	3,004	78	50	61	34	20	55	59
9	255	162	143	445	893	72	42	57	32	23	53	71
10	237	163	153	365	323	181	329	62	26	16	49	63
11	245	4,388	134	282	242	255	190	56	34	29	41	59
12	199	3,638	138	267	209	122	101	50	30	24	36	50
13	152	4,395	150	358	466	73	93	42	29	23	96	116
14	153	1,120	139	327	816	1,967	68	35	33	19	131	374
15	143	809	151	241	349	780	215	34	29	21	77	268
16	148	711	160	203	584	311	280	38	28	19	68	173
17	156	349	152	191	311	231	368	47	36	17	46	171
18	171	304	141	174	217	217	171	44	44	25	373	212
19	164	310	173	176	246	143	401	43	40	25	330	820
20	177	282	184	160	253	111	161	37	31	25	143	445
21	168	135	1,163	146	297	98	120	33	33	30	99	252
22	234	213	651	131	196	97	133	26	31	28	54	172
23	213	202	329	118	278	839	120	25	29	27	382	138
24	152	182	219	125	204	447	84	33	28	23	385	182
25	146	1,555	196	127	198	276	64	34	26	28	1,236	762
26	143	1,661	180	138	173	216	90	30	31	23	1,597	249
27	156	363	184	131	138	153	225	32	30	58	280	203
28	707	225	550	136	181	120	378	27	27	114	168	179
29	1,191	.....	535	121	148	100	171	25	25	87	145	123
30	877	.....	1,302	106	109	88	111	23	35	89	134	102
31	359	.....	1,827	.....	104	.....	84	29	.....	58	.....	91
Mean.	400	819	336	462	343	256	145	45	31	33	210	190

1887.

1	425	274	326	203	118	93	36	1,416	52	101	46	53
2	338	193	264	212	120	136	34	537	50	79	49	40
3	246	184	269	250	110	140	31	259	50	65	42	42
4	153	269	217	242	109	103	29	158	42	82	41	42
5	90	244	198	197	103	57	1,129	133	42	65	40	67
6	85	196	194	157	92	55	1,474	117	53	84	22	95
7	110	674	395	144	173	101	290	139	71	54	23	77
8	99	1,160	969	133	279	115	156	95	53	47	26	63
9	90	874	788	138	286	89	130	83	31	39	39	58
10	76	515	1,156	121	180	71	437	66	29	36	47	124
11	112	899	649	128	139	61	168	66	25	47	59	1,250
12	102	592	324	117	119	47	107	82	559	46	68	372
13	92	244	285	104	96	41	74	84	278	41	51	195
14	908	206	277	104	79	47	62	66	151	46	42	163
15	1,107	648	208	102	63	41	54	54	111	41	54	384
16	401	658	190	112	71	37	49	68	56	33	52	523
17	288	377	163	98	74	36	373	67	63	30	48	207
18	356	2,369	162	143	64	47	129	114	51	40	47	128
19	280	2,061	170	279	55	52	79	128	49	48	47	180
20	205	530	149	322	54	50	68	77	74	45	106	187
21	152	412	160	166	52	55	60	58	53	77	126	267
22	261	501	530	133	45	49	70	58	52	136	91	325
23	641	428	469	146	41	887	627	239	66	72	70	300
24	4,099	703	365	201	54	295	561	919	50	54	57	238
25	869	417	763	155	71	123	214	266	39	66	60	177
26	560	291	546	252	67	73	140	140	48	65	58	174
27	324	809	314	209	54	56	313	96	59	59	47	155
28	255	504	883	159	47	60	126	69	53	48	52	756
29	1,987	.....	477	227	48	47	104	68	62	50	66	995
30	1,069	.....	226	176	57	38	131	70	106	46	56	517
31	445	.....	227	.....	60	.....	1,198	58	.....	44	.....	432
Mean.	523	615	397	171	96	103	273	189	83	58	54	277

Daily discharge in second-feet of Perkiomen Creek at Frederick, Pennsylvania—Continued.

1888.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4,305	109	278	424	129	136	50	31	55	110	108	179
2	3,318	103	279	369	124	82	43	77	49	117	144	149
3	765	121	311	317	112	69	38	24	38	96	136	138
4	429	95	338	248	92	62	31	26	44	72	130	143
5	361	257	232	432	75	57	29	36	40	70	120	135
6	279	604	207	2,750	88	55	29	63	38	69	124	144
7	318	461	183	556	104	52	30	85	34	348	119	134
8	773	272	168	347	101	51	27	52	34	161	101	128
9	528	321	153	279	92	48	25	64	175	109	160	143
10	325	253	193	1,545	92	43	84	60	157	83	541	262
11	241	241	692	1,937	117	46	67	38	99	71	491	173
12	209	156	1,150	525	173	50	44	111	211	79	227	146
13	186	146	352	424	186	82	36	180	229	87	176	120
14	288	150	396	341	155	40	30	99	142	87	159	92
15	234	154	380	314	148	39	23	58	101	87	1,307	115
16	255	168	521	517	138	37	19	42	99	81	715	80
17	209	172	862	456	109	42	22	38	2,691	81	381	4,786
18	201	185	912	284	87	47	19	40	5,306	90	249	2,775
19	174	159	444	247	123	43	18	32	576	88	1,344	601
20	151	1,167	779	251	139	35	27	28	342	107	825	328
21	128	3,285	3,539	241	96	36	27	912	2,804	104	370	265
22	121	1,171	1,533	198	79	32	24	3,336	424	81	275	230
23	112	843	439	174	75	29	19	311	253	85	220	201
24	104	708	347	159	82	32	13	137	194	114	193	174
25	113	2,459	403	151	95	33	15	92	170	141	190	179
26	99	2,322	934	134	118	28	17	60	207	100	225	191
27	121	1,290	1,656	124	111	24	23	52	167	525	368	364
28	144	368	1,009	127	129	32	45	52	125	833	327	469
29	121	312	1,412	120	313	147	55	40	106	592	224	235
30	108	.....	691	118	171	72	46	43	93	270	201	161
31	114	.....	544	.....	124	.....	59	48	.....	184	.....	186
Mean	475	643	676	470	122	53	33	202	500	165	338	433

1889.

1	190	208	75	351	241	2,187	245	1,648	60	153	268	352
2	177	190	125	850	199	729	775	657	80	162	226	335
3	168	185	605	333	171	320	1,401	461	78	187	1,004	314
4	159	169	4,235	231	155	232	1,063	393	70	113	679	278
5	215	174	1,480	190	142	209	715	412	67	103	353	236
6	787	190	628	168	125	182	334	334	71	104	266	246
7	508	166	364	142	115	134	232	229	80	123	224	246
8	310	143	282	123	105	118	182	181	71	115	246	305
9	834	142	218	115	94	116	150	164	72	103	5,389	523
10	918	128	185	106	93	172	133	181	78	90	1,147	327
11	360	123	175	100	158	170	398	173	83	87	560	287
12	290	101	165	109	119	374	264	136	132	90	453	281
13	220	104	160	139	104	239	361	131	222	193	1,792	221
14	203	122	165	143	127	153	440	1,234	252	285	1,421	300
15	183	104	158	113	137	387	4,016	1,613	208	389	508	366
16	178	197	150	105	110	754	550	352	219	231	373	322
17	1,553	791	150	93	86	446	276	227	3,130	150	300	616
18	634	1,182	166	91	76	752	199	181	3,020	131	330	537
19	374	452	173	91	60	244	188	158	603	119	2,268	282
20	209	219	167	82	343	162	458	143	410	115	1,029	355
21	578	185	257	71	745	133	223	131	302	209	725	297
22	526	149	558	82	339	168	157	123	234	186	926	252
23	480	113	302	81	189	119	130	115	173	207	471	234
24	281	101	206	71	134	93	113	115	173	178	347	198
25	340	113	184	63	115	90	104	107	439	140	816	193
26	359	114	150	593	148	881	96	100	416	134	620	349
27	724	102	137	1,894	630	627	132	98	261	3,356	670	285
28	871	82	173	1,210	723	249	172	90	185	1,202	2,803	202
29	393	.....	175	536	268	175	163	84	153	451	715	181
30	248	.....	143	262	177	225	598	74	139	294	462	171
31	235	.....	126	.....	232	.....	5,567	67	.....	256	.....	161
Mean	436	216	395	285	208	361	640	326	383	311	913	298

Discharge in second-feet of Perkiomen Creek at Frederick, Pennsylvania—Continued.

1890.

r.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
...	151	192	687	415	133	104	45	54	83	55	140	64
...	189	156	372	377	135	136	447	62	71	57	129	84
...	171	213	289	290	117	176	535	49	60	948	125	78
...	193	249	237	1,246	153	167	304	49	64	249	118	125
...	188	298	225	1,124	1,084	117	149	54	69	137	115	130
...	238	192	202	387	536	127	95	74	63	182	112	110
...	186	148	190	360	456	179	71	77	62	451	106	116
...	172	3,699	245	381	283	120	60	65	59	329	89	133
...	152	7,051	165	1,149	220	98	58	148	59	192	83	124
...	141	445	215	847	181	89	52	88	64	135	91	94
...	142	1,521	736	407	165	92	48	64	54	112	138	93
...	132	303	806	316	243	243	43	70	57	108	196	86
...	143	257	444	277	145	664	38	62	796	102	140	85
...	132	1,030	1,156	254	510	189	37	85	331	135	117	80
...	1,368	874	1,397	225	1,172	125	52	95	842	143	104	70
...	1,215	325	626	199	436	103	72	64	876	122	92	71
...	440	287	412	191	268	97	88	45	453	821	200	314
...	202	257	351	177	202	95	125	92	213	264	308	1,006
...	236	228	306	171	175	79	89	119	161	186	174	298
...	386	827	352	167	288	60	61	803	120	191	136	183
...	341	827	1,507	157	375	67	46	260	95	156	112	132
...	201	248	4,048	146	187	122	54	267	91	129	102	145
...	144	212	2,082	139	147	105	53	162	87	623	92	136
...	154	363	699	143	133	107	48	106	75	1,754	91	121
...	154	357	510	198	122	93	109	91	71	632	94	104
...	145	332	855	215	1,514	64	1,018	91	60	349	80	135
...	190	259	425	200	2,510	55	212	699	98	246	79	108
...	129	527	1,583	203	497	49	115	256	86	191	73	97
...	138	.....	801	160	278	48	113	139	71	173	76	100
...	368	.....	459	142	206	50	103	124	68	238	71	108
...	254	.....	395	.....	179	.....	71	101	.....	171	.....	93
an	271	774	735	355	421	127	142	146	179	309	119	149

1891.

...	75	1,917	238	433	105	48	28	163	236	54	51	196
...	1,961	892	206	364	108	54	28	113	210	48	42	53
...	941	760	288	870	214	50	34	84	156	50	42	51
...	298	607	201	421	243	46	36	172	129	38	37	1,225
...	219	322	211	315	139	45	33	187	2,367	38	44	1,184
...	176	260	199	242	115	40	36	146	880	38	49	256
...	149	451	217	211	94	66	33	144	396	42	37	734
...	128	762	236	179	90	117	43	74	235	73	27	456
...	101	652	711	174	92	78	77	53	178	88	30	225
...	94	977	1,260	165	78	52	53	48	145	59	38	169
...	1,705	424	509	379	83	41	37	46	120	42	89	113
...	3,431	303	551	786	76	37	29	45	108	49	124	75
...	400	272	1,352	320	65	36	23	58	99	51	71	75
...	246	239	630	233	67	32	31	58	91	45	59	75
...	206	181	314	205	68	34	45	220	85	42	41	75
...	168	1,312	462	181	96	38	43	151	80	49	52	75
...	206	1,323	233	180	97	38	38	86	77	49	123	75
...	453	781	224	177	77	55	162	228	71	40	193	75
...	304	410	209	160	78	69	413	406	66	31	110	75
...	239	383	883	147	72	65	142	155	51	275	71	60
...	209	832	4,803	135	70	58	73	109	52	173	79	59
...	3,945	1,012	1,275	140	67	84	54	176	66	134	50	80
...	970	432	1,007	158	59	73	47	116	49	220	114	895
...	390	339	640	155	61	54	81	1,169	45	118	303	1,197
...	539	342	426	129	59	36	91	1,915	53	72	138	928
...	446	397	325	107	60	30	47	374	49	67	100	791
...	379	381	298	111	72	20	45	355	47	79	94	779
...	341	215	299	113	65	27	46	573	47	79	83	408
...	782	.....	278	104	51	26	812	274	40	70	66	307
...	1,315	.....	245	103	55	28	425	362	52	48	49	725
...	852	.....	.....	.....	.....	.....	352	368	.....	48	.....	261
n.	699	613	624	247	89	49	111	272	209	74	80	379

Daily discharge in second-feet of Perkiomen Creek at Frederick, Pennsylvania—Continued.

1892.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	201	184	2,073	229	83	127	275	239	75	26	31	174
2	1,482	202	610	213	100	105	184	146	67	24	29	130
3	861	217	246	237	167	90	375	211	56	22	26	117
4	303	178	338	238	153	479	557	126	36	26	26	106
5	235	201	319	203	122	150	192	71	32	28	34	100
6	196	146	311	183	106	144	111	52	33	24	32	89
7	204	155	393	164	114	124	78	45	34	22	26	71
8	214	191	1,673	153	95	96	58	41	32	27	27	427
9	198	216	1,341	138	85	93	51	37	29	28	32	369
10	180	185	625	125	84	429	46	36	28	26	295	186
11	158	173	437	122	71	182	45	134	31	30	319	130
12	182	126	458	120	77	110	42	359	23	32	133	116
13	3,674	121	262	112	74	84	40	135	20	26	76	120
14	3,769	137	190	127	94	69	38	62	71	26	54	357
15	1,066	147	207	265	263	53	39	51	90	29	652	550
16	572	154	178	212	214	50	37	51	54	23	2,836	297
17	412	113	167	146	102	297	27	39	40	24	472	231
18	404	96	145	133	111	149	32	34	34	29	769	180
19	1,879	97	153	128	117	71	31	35	27	31	602	152
20	699	131	150	111	397	71	26	28	23	30	268	142
21	412	159	165	129	365	77	36	25	27	31	192	124
22	316	154	153	204	420	57	36	24	33	30	156	112
23	300	158	173	247	337	41	23	24	42	29	168	117
24	275	151	462	169	241	49	18	26	56	40	88	100
25	288	144	906	131	160	65	18	51	59	43	76	48
26	251	189	570	125	872	59	20	571	61	33	84	58
27	207	209	1,688	106	1,491	64	23	155	58	30	68	58
28	178	155	1,074	87	400	171	22	87	46	29	326	52
29	176	158	1,479	91	219	102	88	68	40	17	506	45
30	185	.....	315	102	175	80	176	62	57	4	229	35
31	168	.....	259	.....	155	.....	379	72	.....	32	.....	33
Mean.	634	166	565	158	241	125	101	100	44	27	288	155

1893.

1	258	257	213	157	249	78	36	21	50	26	43	108
2	1,169	597	264	144	343	78	37	30	46	30	41	143
3	268	702	252	138	998	158	37	25	46	27	42	301
4	166	535	202	136	5,139	96	36	22	44	24	867	806
5	128	335	184	118	857	86	36	19	43	25	1,470	265
6	128	244	187	101	979	156	34	16	41	25	372	199
7	94	1,021	168	113	479	197	35	14	36	30	202	204
8	93	714	217	208	349	107	35	15	38	29	158	158
9	122	383	2,224	177	283	68	63	18	41	26	386	137
10	138	3,247	3,546	190	185	59	62	22	32	27	168	168
11	128	1,534	1,221	392	201	51	46	24	32	28	102	243
12	165	512	3,401	345	185	54	40	24	38	29	84	171
13	170	602	1,493	172	177	58	39	22	28	32	87	126
14	145	854	1,039	436	177	49	39	22	25	1,939	91	101
15	132	913	937	1,537	183	44	33	19	40	105	160	109
16	138	1,190	385	506	260	38	97	14	978	53	177	989
17	169	566	320	299	548	37	118	13	315	50	112	1,091
18	190	300	325	235	249	37	60	13	140	36	88	346
19	174	318	297	196	175	43	42	16	93	30	71	226
20	165	251	275	486	138	40	33	1,129	67	34	76	137
21	172	224	353	1,061	122	38	24	289	52	34	84	139
22	173	226	369	407	115	63	22	92	43	34	341	121
23	171	193	315	268	116	86	26	55	39	38	231	135
24	160	173	340	212	115	71	31	1,166	34	74	133	137
25	138	163	335	201	106	43	28	269	33	78	104	141
26	118	153	300	195	97	77	23	110	36	45	78	177
27	102	147	240	320	91	93	21	59	38	43	83	113
28	102	166	206	355	88	67	24	44	29	263	1,118	98
29	116	.....	178	211	97	54	26	187	21	161	347	129
30	258	.....	172	186	96	39	23	150	25	93	196	149
31	304	.....	169	.....	84	.....	14	69	.....	65	.....	117
Mean.	192	591	649	317	428	72	39	129	83	113	251	241

Daily discharge in second-feet of Perkiomen Creek at Frederick, Pennsylvania—Continued.

1894.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	109	138	166	120	98	509	131	23	17	36	412	78
2	101	120	197	120	76	348	82	88	27	36	193	339
3	101	98	464	109	57	277	70	154	25	46	908	364
4	97	68	776	149	61	235	45	109	14	55	428	176
5	120	74	822	333	64	212	40	57	15	63	805	126
6	153	88	1,045	175	103	207	571	42	15	51	786	114
7	145	80	1,024	135	128	206	241	35	17	38	369	103
8	125	88	524	128	91	191	99	29	249	45	350	125
9	111	704	360	123	67	167	68	31	483	36	429	387
10	92	1,002	311	117	52	143	55	33	137	2,335	303	223
11	74	638	280	168	48	131	43	31	292	530	261	638
12	62	343	249	329	48	118	38	31	101	182	188	4,132
13	59	198	214	1,119	41	118	38	35	59	209	165	1,641
14	58	182	188	898	36	121	36	52	43	290	161	446
15	67	172	169	446	38	104	34	57	43	160	146	326
16	80	160	176	239	38	91	224	47	40	118	123	266
17	89	152	170	229	37	84	44	43	63	98	133	226
18	92	975	136	190	40	80	29	35	1,123	80	178	187
19	80	1,175	136	170	52	81	23	41	2,490	59	130	161
20	69	1,284	142	163	1,634	77	23	57	934	51	111	151
21	56	632	132	183	8,769	72	31	50	243	48	115	145
22	74	442	161	269	3,787	64	46	46	144	49	126	136
23	88	308	479	262	539	60	38	40	99	55	119	117
24	80	163	291	168	3,541	132	48	38	90	61	120	114
25	97	187	156	138	1,398	298	75	36	71	717	101	111
26	88	165	195	121	708	113	45	30	47	309	95	137
27	62	154	181	113	566	94	38	24	54	179	100	123
28	55	157	126	105	2,442	85	38	22	51	130	78	130
29	76	.....	158	93	1,822	68	37	32	46	108	70	145
30	147	.....	168	94	541	132	35	26	43	98	72	119
31	168	.....	138	.....	519	.....	31	14	.....	513	.....	102
Mean	93	355	314	234	885	154	77	45	23	219	252	374

1895.

1	102	138	1,192	168	236	51	393	31	30	16	84	51
2	80	128	1,235	327	163	47	151	34	30	16	82	43
3	80	122	454	463	133	43	70	34	33	18	64	155
4	86	136	418	252	128	62	56	35	31	20	47	95
5	84	143	416	181	114	79	667	39	31	25	54	67
6	115	86	240	158	101	138	489	31	29	5	54	55
7	607	98	249	143	108	115	172	22	22	21	44	45
8	839	158	1,238	1,910	106	70	105	24	19	8	45	43
9	544	178	789	4,203	94	50	71	28	23	19	44	38
10	354	222	689	682	78	50	48	24	26	13	33	41
11	2,372	243	711	390	73	55	45	75	26	17	49	45
12	905	214	323	296	134	44	40	133	22	25	65	37
13	566	196	845	1,018	151	52	39	104	18	117	38	33
14	333	186	1,528	845	205	68	37	58	16	177	43	33
15	244	171	448	393	271	55	33	39	6	63	26	30
16	242	152	312	286	151	40	37	31	24	50	52	31
17	249	136	242	232	114	36	43	31	20	41	46	25
18	187	134	313	200	101	34	40	31	18	29	49	29
19	157	141	512	175	87	30	36	29	22	33	55	30
20	137	154	476	151	80	28	31	18	26	11	52	119
21	136	184	317	156	91	30	26	18	26	22	41	127
22	142	225	324	154	120	34	23	26	20	25	36	486
23	151	193	306	154	92	36	26	27	27	24	35	197
24	148	118	334	138	76	32	33	23	27	26	18	118
25	125	114	456	126	72	31	36	18	24	22	39	86
26	2,212	117	498	126	59	35	27	19	24	24	37	71
27	559	198	282	266	236	88	21	23	22	12	39	117
28	235	820	280	247	348	104	23	24	22	33	131	117
29	191	.....	222	177	139	87	21	26	4	21	85	71
30	178	.....	181	236	85	141	34	38	18	21	55	110
31	165	.....	161	.....	66	.....	30	41	.....	24	.....	1,191
Mean	404	182	516	475	129	59	94	37	23	32	51	120

Daily discharge in second-feet of Perkiomen Creek at Frederick, Pennsylvania—Continued.

1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	327	56	586	351	63	65	51	123	21	179	42	236
2	150	91	338	322	55	53	39	84	20	60	43	160
3	124	106	188	256	57	42	44	73	21	45	54	126
4	91	111	124	189	71	39	41	64	22	38	57	125
5	58	85	119	161	71	36	38	45	38	45	2,439	116
6	47	6,789	95	156	50	34	36	40	758	66	829	97
7	42	2,181	99	166	45	28	39	40	212	60	295	109
8	31	381	92	148	49	30	60	35	81	41	344	120
9	37	347	72	117	42	41	260	28	52	41	377	406
10	40	335	78	120	34	91	457	83	42	39	217	223
11	35	291	80	133	37	95	133	66	39	33	191	150
12	34	196	59	120	38	44	69	35	30	585	282	118
13	34	177	63	108	37	31	47	34	24	2,711	231	102
14	37	569	67	99	23	36	41	32	23	476	178	100
15	38	360	55	86	39	78	40	25	30	259	137	98
16	31	415	60	80	39	82	41	25	39	164	119	85
17	20	121	82	81	25	118	38	26	37	122	113	87
18	22	123	96	98	25	177	33	31	358	98	100	95
19	30	112	1,854	109	32	75	25	34	95	82	89	81
20	31	112	3,150	89	34	49	23	32	81	71	82	60
21	34	90	875	125	65	39	1,532	32	56	63	77	73
22	34	54	618	127	92	40	863	31	52	63	75	70
23	36	52	521	83	65	36	1,143	25	39	52	84	55
24	193	93	259	81	38	37	169	26	31	125	88	58
25	379	116	316	149	35	66	115	31	30	138	87	58
26	156	75	655	114	35	94	79	26	33	82	72	55
27	105	70	700	84	38	125	70	26	34	68	65	52
28	86	69	301	78	165	71	177	31	26	60	175	55
29	60	638	2,520	66	300	124	297	24	36	57	895	58
30	43	.....	1,052	67	119	88	1,938	17	287	57	379	47
31	43	.....	465	.....	74	.....	250	20	.....	53	.....	36
Mean	78	493	504	132	61	65	264	41	88	195	280	107

1897.

1	51	46	131	88	82	105	45	86	35	22	70	136
2	78	55	128	85	2,580	88	46	180	113	18	3,089	113
3	85	55	162	76	1,330	80	33	61	159	13	103	95
4	124	49	246	67	381	124	30	54	75	17	169	161
5	318	55	211	139	268	180	34	213	67	17	100	1,942
6	547	965	545	200	199	150	34	117	37	10	70	513
7	83	4,083	315	149	148	105	29	58	33	15	47	386
8	76	846	200	115	124	118	35	55	29	22	34	207
9	61	346	172	1,643	112	899	43	45	34	18	96	168
10	51	204	180	988	124	473	38	53	32	8	120	146
11	52	171	198	311	131	106	30	201	13	15	84	133
12	47	123	221	218	138	127	203	120	8	23	106	360
13	38	110	212	185	4,747	106	248	66	29	22	88	355
14	49	115	168	153	1,566	97	38	49	29	29	41	1,909
15	45	110	199	323	1,003	84	56	48	33	28	44	2,561
16	39	161	189	316	425	75	44	149	36	17	60	229
17	46	184	129	265	365	75	41	167	29	16	87	325
18	117	413	139	216	300	85	213	68	26	27	97	249
19	150	351	322	166	173	85	292	50	23	30	70	185
20	96	153	730	129	153	64	130	47	19	14	51	145
21	1,291	347	392	116	217	61	104	41	23	16	51	151
22	504	664	242	110	221	63	588	39	25	23	67	166
23	157	1,242	201	99	137	63	231	33	22	20	60	141
24	115	457	564	94	202	51	128	30	35	28	60	99
25	136	244	405	80	442	46	77	112	46	88	62	73
26	130	193	208	84	201	50	60	123	38	89	93	71
27	93	158	167	94	126	37	475	52	29	62	1,117	89
28	81	136	146	76	103	35	1,901	37	31	50	317	94
29	69	.....	128	70	93	38	729	26	27	49	219	82
30	51	.....	120	61	83	35	236	27	22	47	183	88
31	48	.....	98	.....	99	.....	127	28	.....	39	.....	130
Mean	156	429	241	223	525	128	205	78	40	29	238	364

ischarge in second-feet of Perkiomen Creek at Frederick, Pennsylvania—Continued.

1898.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
..	163	145	153	292	201	113	29	32	40	28	129	363
..	37	137	138	213	160	103	30	38	28	20	90	242
..	69	147	168	178	147	96	34	46	23	29	76	233
..	62	129	183	157	141	93	29	49	19	31	70	1,916
..	45	114	153	151	148	75	29	139	27	23	78	3,406
..	59	114	127	171	199	60	30	104	25	21	63	569
..	101	116	115	184	497	63	28	50	34	18	45	352
..	121	125	115	155	3,493	59	29	43	51	23	94	218
..	102	140	107	129	1,360	46	57	116	45	26	52	100
..	94	182	107	113	495	37	64	332	29	31	1,422	102
..	106	348	102	121	398	39	39	393	25	27	1,100	92
..	205	541	99	127	495	46	35	145	22	27	272	97
..	302	414	99	108	580	54	37	82	19	30	173	100
..	253	307	98	106	415	50	37	56	24	30	167	91
..	542	248	89	323	1,403	41	37	44	25	56	150	78
..	661	272	76	259	1,013	50	37	43	17	56	103	70
..	296	159	85	170	713	56	18	45	15	40	202	72
..	166	166	88	122	377	44	28	46	13	45	447	78
..	147	258	88	113	392	49	39	258	12	39	3,808	111
..	585	5,552	74	126	289	64	190	71	14	71	602	890
..	704	1,650	133	125	345	66	115	60	17	57	312	384
..	375	739	426	102	232	56	73	51	27	162	233	552
..	2,758	474	445	95	211	53	51	50	42	116	763	1,364
..	570	332	341	658	255	51	41	47	54	61	403	452
..	323	265	340	428	422	39	37	47	61	60	317	308
..	454	218	220	433	353	36	39	39	52	235	267	215
..	393	182	173	285	268	37	40	35	43	475	207	189
..	261	166	282	481	219	41	65	30	43	163	213	150
..	205	.....	414	641	168	45	74	24	45	93	330	126
..	166	.....	894	312	153	41	48	24	38	111	395	139
..	166	.....	456	.....	131	.....	37	38	.....	198	.....	230
..	338	486	206	229	505	56	44	83	30	77	416	428

1899.

..	313	131	651	346	78	76	84	72	53	147	294	68
..	239	130	635	262	82	66	52	346	440	101	286	114
..	239	120	589	248	98	49	45	722	922	99	181	84
..	222	182	753	252	101	38	41	177	318	101	724	69
..	1,014	193	3,525	230	84	36	41	90	174	93	309	71
..	1,315	143	975	185	83	36	41	77	106	98	184	56
..	1,476	148	588	245	74	38	36	66	57	119	138	55
..	394	152	391	1,366	70	39	41	52	43	105	109	64
..	311	174	365	428	87	41	816	48	290	95	107	56
..	239	183	345	296	73	48	163	157	227	80	104	44
..	195	158	475	251	101	49	71	1,021	213	72	88	43
..	165	170	1,519	219	213	43	43	224	369	67	110	146
..	150	222	1,552	187	129	38	42	90	189	57	112	250
..	245	236	510	178	125	39	43	66	97	53	62	127
..	410	225	848	170	123	44	38	54	71	57	62	84
..	475	255	879	260	83	34	35	46	54	48	92	75
..	789	233	437	501	93	26	38	52	46	51	77	67
..	443	683	853	263	201	29	42	42	55	65	60	55
..	196	992	2,423	196	210	27	42	37	58	80	58	133
..	192	1,311	780	160	129	26	40	36	748	81	67	182
..	164	1,495	421	146	86	82	33	29	385	67	65	127
..	145	1,507	1,146	136	70	65	27	53	206	63	53	79
..	147	1,767	893	118	96	41	25	61	184	57	159	57
..	1,081	869	517	113	98	43	25	44	115	49	200	662
..	2,693	469	417	120	70	83	26	39	110	34	116	531
..	378	1,184	534	114	57	110	70	34	3,363	34	79	177
..	289	4,043	513	99	60	74	82	502	462	60	75	133
..	212	883	1,002	87	60	165	98	197	258	62	81	91
..	201	.....	1,377	81	71	501	89	84	174	51	66	59
..	153	.....	555	76	122	220	817	64	168	71	65	51
..	129	.....	466	.....	93	.....	158	63	.....	78	.....	47
).	472	659	869	245	100	74	104	150	332	74	139	124

WISSAHICKON CREEK NEAR PHILADELPHIA, PENNSYLVANIA.

The drainage basin of this creek is immediately adjacent to Philadelphia, and between Little Neshaminy and Perkiomen creeks. Measurements of flow were begun in April, 1897, under the direction of Mr. John E. Codman, at a point about 100 yards above the junction of the creek with Schuylkill River. The results for 1897 and 1898 have been printed in the Twentieth Annual Report, Part IV, and the daily flow to June 1, 1899, is given in the following table:

Daily discharge in second-feet of Wissahickon Creek, near Philadelphia, Pennsylvania, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	141	119	285	191	89	45	18	147	227	273	129	96	.....
2	106	106	245	175	96	42	19	118	350	603	129	90	.....
3	106	110	233	175	103	42	20	116	466	340	123	73	.....
4	120	204	233	173	93	33	21	115	436	202	115	68	.....
5	412	204	1,059	159	80	21	22	106	779	521	106	75	.....
6	574	113	365	151	80	.....	23	106	630	328	106	96	.....
7	573	113	241	166	87	.....	24	259	359	232	106	96	.....
8	220	113	204	451	87	.....	25	925	250	202	106	75	.....
9	194	113	186	205	75	.....	26	184	245	216	106	64	.....
10	154	113	198	152	75	.....	27	142	1,285	198	106	64	.....
11	140	113	198	140	105	.....	28	133	423	434	101	54	.....
12	132	113	198	140	108	.....	29	136	.....	813	98	50	.....
13	118	113	540	140	90	.....	30	136	.....	260	95	59	.....
14	144	113	208	137	87	.....	31	136	.....	218	.....	54	.....
15	149	113	346	129	87	.....							
16	140	113	359	142	87	.....	Mean	207	271	326	146	81	.....
17	232	149	186	142	87	.....							

SCHUYLKILL RIVER NEAR PHILADELPHIA, PENNSYLVANIA.

This river receives the drainage of the portion of southeastern Pennsylvania lying between the Lehigh River on the north and the Susquehanna River on the south. It flows in a general southeasterly course, emptying into Delaware River, the city of Philadelphia being located at the junction of these streams. Records of the height of the river at Fairmount pool have been kept for many years, but not in such form as to be useful in computing daily discharges. In 1898, however, careful estimates were prepared by Mr. John E. Codman, the results being given in the Twentieth Annual Report, Part IV, page 97. The figures for 1899 are given in the following table:

These do not represent the total flow of the stream, but the amount wasted over the flashboards at Fairmount dam. To this must be added the pumpage from the river, amounting to 275,000,000 gallons per day, or 425 second-feet; also the leakage, amounting to 71,000,000 gallons per day, or 110 second-feet; also the quantity used for power at Fairmount, amounting to an average per day of 272,000,000 gallons, or 421 second-feet. There has been no method for obtaining the daily flow when the water does not waste over the flashboards. When the water is below the overflow line recourse is had to pumping, and the draft is on the storage of the pool. As soon as the water begins to rise after a rain the turbine wheels are started and, thus it often

ccurs that no water flows to waste for from one to three months in uccession.

Daily discharge in second-feet of Schuylkill River above Philadelphia, Pennsylvania, for 1899, being amount wasted over flashboards at Fairmount Dam.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	573	566	11,170	5,321	.....	440	385	514	.....	.....	60	.....
2	170	566	8,532	4,156	.....	204	.....	.....	.....	.....	605	.....
3	26	347	6,717	3,352	.....	341	.....	2,421	964	.....	477	.....
4	135	1,023	6,421	2,910	.....	179	.....	414	217	.....	1,961	.....
5	3,033	1,250	17,735	2,481	.....	.....	.....	.....	.....	.....	3,002	.....
6	6,017	781	13,186	2,210	.....	.....	.....	.....	.....	.....	1,415	.....
7	8,945	825	4,748	2,945	.....	.....	.....	.....	.....	.....	703	.....
8	2,521	342	7,120	7,735	.....	.....	.....	.....	.....	.....	831	.....
9	1,470	31	5,504	7,651	.....	.....	1,185	.....	.....	.....	733	.....
10	1,035	.....	4,805	5,068	46	.....	385	.....	179	.....	622	.....
11	816	.....	4,468	3,824	.....	.....	.....	4,775	.....	.....	.....	.....
12	511	.....	4,961	3,920	357	.....	.....	2,213	173	.....	.....	.....
13	248	.....	11,906	2,478	369	.....	.....	641	130	.....	83	857
14	436	.....	7,918	2,478	31	.....	.....	.....	.....	.....	83	1,012
15	693	.....	7,046	2,478	.....	.....	.....	.....	.....	.....	.....	159
16	950	50	8,948	2,478	.....	.....	.....	.....	.....	.....	.....	260
17	1,854	902	5,619	2,902	.....	.....	.....	.....	.....	.....	.....	.....
18	1,421	3,301	5,310	2,478	277	.....	.....	.....	.....	.....	.....	68
19	569	3,858	14,442	2,075	1,061	.....	.....	.....	.....	.....	.....	570
20	523	4,990	10,540	1,582	532	.....	.....	.....	550	.....	.....	610
21	526	5,908	10,748	1,012	240	.....	.....	.....	1,489	.....	.....	331
22	305	8,656	11,230	849	25	.....	.....	.....	1,042	.....	.....	331
23	305	9,746	11,548	337	.....	.....	.....	.....	49	.....	.....	.....
24	4,226	4,914	8,034	212	.....	.....	.....	.....	.....	.....	397	1,201
25	14,980	4,984	6,326	.....	.....	.....	.....	.....	.....	.....	397	3,854
26	7,082	1,605	6,134	.....	.....	624	.....	.....	10,923	.....	.....	2,902
27	1,752	17,177	5,874	.....	.....	241	.....	1,775	5,653	.....	.....	2,489
28	1,951	18,045	8,622	.....	.....	.....	.....	637	2,155	.....	.....	2,077
29	1,175	.....	13,757	.....	.....	1,238	.....	.....	1,154	.....	.....	1,277
30	967	.....	9,085	.....	.....	1,752	215	468	494	.....	.....	298
31	1,120	.....	6,718	.....	519	.....	1,920	336	.....	.....	.....	.....

Total monthly yield, in cubic feet, of Schuylkill River above Philadelphia, Pennsylvania, for 1899.

January	11,445,838,000	July	3,475,700,000
February	12,484,000,000	August	3,964,400,000
March	28,187,700,000	September	5,258,910,000
April	11,957,000,000	October	2,587,900,000
May	5,158,450,000	November	4,896,500,000
June	3,856,560,000	December	5,086,600,000

NORTH BRANCH OF SUSQUEHANNA RIVER AT WILKESBARRE, PENNSYLVANIA.

This stream rises in New York State and flows in a southwesterly lirection until it crosses the Pennsylvania State line, when it flows to he southeast, turning again near Wilkesbarre to the southwest, and oins the West Branch of the Susquehanna on the western border of Northumberland County to form Susquehanna River. Measurements of flow are made at Wilkesbarre and Danville, Pennsylvania.

Observations of fluctuations of Susquehanna River are made by he Weather Bureau above Wilkesbarre, at Towanda, Pennsylvania, where the drainage area is estimated to be 8,000 square miles. The iver gage, made of iron 1 foot wide and one-half inch thick, is on the east side of the road bridge over Susquehanna River, and is securely bolted to the masonry of the pier. The graduation is from 0 to 25 feet. The highest water was 29 feet in March, 1869, and the lowest,

—0.1, in October, 1895. The danger line is at 16 feet. The elevation of the zero is 633.7 feet.

The Wilkesbarre station was established by E. G. Paul on March 30, 1899, and is located at the Market street bridge. The gage is a sash chain and weight inclosed in a long, narrow box, covering 12 feet of the scale board. The scale board is divided into feet and tenths and painted the color of the ironwork. The length of the chain from zero to extreme end of weight is 40.83 feet. The initial point of sounding is at the end of the iron guard rail on the left bank. The channel is straight for a quarter of a mile above and below the station, the current sluggish but unobstructed. The right bank is low and liable to overflow; the left bank is above ordinary floods. The bed of the stream is of sand and gravel, somewhat shifting. The observer is O. Hemstreet, the bridge superintendent, Wilkesbarre, Pennsylvania. When this gage was established there was found to be a gage painted on the bridge pier, being a portion of one established by the Weather Bureau. The lower part of this gage, erected in January, 1898, originally consisted of heavy cast-brass plates graduated to feet and tenths. The gage plates were made in 4-foot sections and bolted to the stone bridge pier. The two lower sections of the brass plates had been torn away by ice, so that there was no graduation below the 8-foot mark, but readings were made by the figures painted on the stone pier. The zero of this old gage is at the base of the dressed-stone portion of the pier, and is reported to be 535 feet above sea level. During low stages of the river the water recedes from the pier, rendering it impracticable to read the gage. So far as could be ascertained, this has not been connected with the city datum. On account of the low water, which in 1897 had gone below the city datum, it was decided to put the zero of the new gage 4 feet below the zero of the old Weather Bureau gage, so as to obviate minus readings. In order, therefore, to compare with former records, it is necessary to add 4 feet to the old figures. The danger mark of this Weather Bureau gage is at 14 feet, or 18 feet of new gage, as at this elevation the west bank of the river is under water in places. River reports from this locality were furnished as early as 1888. During low water, measurements were made by wading at a better cross section, at Retreat, 10 miles below Wilkesbarre. The following measurements were made by E. G. Paul during 1899:

Measurements of North Fork of Susquehanna River at Wilkesbarre, Pennsylvania.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Second-ft.*	1899.	*Feet.*	*Second-ft.*
March 30	9.00	24,800	September 17	2.30	851
June 6	4.30	3,668	September 18	2.30	a 1,096
July 26	2.80	a 1,924	October 16	2.35	a 1,114
July 27	2.80	1,357			

a Made at Retreat, Pennsylvania, 10 miles below Wilkesbarre.

ily gage height, in feet, of North Branch of Susquehanna River at Wilkesbarre, Pennsylvania, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	8.40	6.40	4.50	3.60	2.70	3.10	2.50	2.50	3.40
2	.....	8.10	6.20	5.50	3.30	2.60	2.90	2.50	3.00	3.40
3	.....	7.70	6.30	5.30	3.30	2.70	2.60	2.50	8.30	3.40
4	.....	7.20	6.30	5.10	3.20	2.60	2.60	2.50	6.70	3.40
5	.....	6.90	6.40	4.60	3.00	3.20	2.50	2.50	7.30	3.50
6	.....	6.90	6.10	4.30	3.00	3.00	2.50	2.60	6.60	3.50
7	.....	7.40	5.70	3.60	2.80	2.80	2.50	2.60	6.90	3.50
8	.....	10.35	5.60	3.50	2.90	2.50	2.40	2.50	5.30	3.70
9	.....	14.10	5.40	3.50	2.80	2.50	2.40	2.50	5.00	3.60
10	.....	14.20	5.30	3.50	2.80	2.50	2.40	2.50	4.50	3.50
11	.....	12.80	5.10	3.30	2.80	2.50	2.40	2.50	4.20	3.50
12	.....	11.10	5.20	3.20	2.90	2.50	2.50	2.50	4.30	3.60
13	.....	11.30	5.10	3.20	2.90	2.70	2.50	2.40	4.90	7.70
14	.....	14.00	5.00	3.20	3.00	2.80	2.50	2.40	4.70	9.60
15	.....	14.30	5.00	3.00	3.20	2.80	2.40	2.40	4.60	9.60
16	.....	13.90	4.80	3.10	3.30	2.80	2.40	2.40	4.50	8.50
17	.....	13.40	4.80	3.20	3.10	2.90	2.30	2.30	5.20	7.70
18	.....	12.50	4.70	3.20	3.00	2.70	2.30	2.30	5.20	7.30
19	.....	11.30	4.90	3.00	3.00	2.40	2.30	2.30	5.30	6.50
20	.....	10.50	4.90	3.00	3.00	2.30	2.30	2.30	5.00	6.50
21	.....	9.90	5.40	3.10	3.10	2.30	2.30	2.30	4.70	8.30
22	.....	9.40	5.90	3.00	3.00	2.60	2.30	2.30	4.60	8.40
23	.....	9.00	5.80	3.00	3.00	2.50	2.30	2.30	4.30	7.40
24	.....	8.50	5.70	2.90	2.90	2.50	2.30	2.30	4.20	6.60
25	.....	8.00	5.50	2.90	2.80	2.40	2.20	2.30	4.00	8.40
26	.....	7.40	5.40	3.10	2.80	2.40	2.50	2.20	3.80	8.00
27	.....	7.60	5.10	3.10	2.80	2.40	2.40	2.30	3.80	7.40
28	.....	7.40	4.90	3.30	2.80	2.40	2.50	2.30	3.70	6.30
29	.....	7.10	4.80	3.80	2.80	4.60	2.50	2.50	3.60	9.10
30	9.00	6.60	4.80	4.00	2.60	4.10	2.60	2.50	3.50	7.90
31	8.70	.....	4.70	.....	2.60	3.40	.....	2.50	.....	.....

NORTH BRANCH OF SUSQUEHANNA RIVER AT DANVILLE, PENNSYLVANIA.

This station, 52 miles below Wilkesbarre and 11 miles above the outh of the West Branch, was established on March 25, 1899, by . G. Paul. It is located at the Mill street bridge, 600 feet south of the ublic square, Danville, Pennsylvania. The length of the wire gage rom zero to the end of the weight is 42.85 feet. This gage is referred to pine-board scale nailed to the hand rail of the bridge and divided into eet and tenths. The initial point of soundings is at the end of the rooden hand rail on right bank. The channel is straight for half a ile above and below the station. The left bank is high, but the right ank is subject to overflow. The bed of the stream is rocky, with ome gravel, and is unchangeable. The following measurements ere made by E. G. Paul during 1899:

March 25, gage height, 10.00 feet; discharge, 47,646 second-feet.
June 8, gage height, 3.00 feet; discharge, 3,927 second-feet.
July 27, gage height, 2.40 feet; discharge, 2,272 second-feet.
September 16, gage height, 2.00 feet; discharge, 1,427 second-feet.
October 17, gage height, 1.90 feet; discharge, 1,163 second-feet.

Daily gage height, in feet, of North Branch of Susquehanna River at Danville, Pennsylvania, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	6.95	4.80	3.30	3.20	2.20	2.80	2.10	2.10	3.10
2	.....	6.40	4.65	3.40	3.00	2.30	2.60	2.10	2.60	3.00
3	.....	6.35	4.60	3.70	2.80	2.60	2.50	2.10	2.60	3.00
4	.....	6.00	4.60	3.60	2.70	2.30	2.50	2.10	6.10	3.00
5	.....	5.45	4.60	3.50	2.60	2.20	2.30	2.00	5.40	3.00
6	.....	5.30	4.55	3.30	2.60	2.25	2.20	2.00	5.70	2.90
7	.....	5.65	4.35	3.20	2.60	2.50	2.20	2.00	5.20	3.10
8	.....	6.90	4.15	3.00	2.50	2.30	2.10	2.00	4.70	3.10
9	.....	10.50	3.80	3.00	2.50	2.20	2.40	2.10	4.30	3.10
10	.....	11.00	3.70	2.90	2.50	2.20	2.20	2.10	3.90	3.00
11	.....	10.45	3.70	2.90	2.50	2.60	2.10	2.00	7.30	3.00
12	.....	9.15	3.75	2.90	2.40	2.30	2.20	2.00	3.90	3.10
13	.....	8.95	3.80	2.70	2.60	2.40	2.10	2.00	3.70	4.20
14	.....	10.75	3.70	2.70	2.70	2.30	2.10	1.90	4.00	6.80
15	.....	11.55	3.70	2.60	2.60	2.30	2.10	1.90	3.90	7.80
16	.....	11.40	3.60	2.60	2.80	2.35	2.00	1.90	3.80	7.60
17	.....	10.85	3.60	2.60	2.80	2.30	1.90	1.90	3.90	6.70
18	.....	10.05	3.70	2.60	2.70	2.30	1.90	1.90	4.30	6.10
19	.....	9.05	3.60	2.60	2.70	2.30	1.80	1.90	4.40	5.70
20	.....	8.25	3.60	2.50	2.50	2.20	1.80	1.90	4.30	5.40
21	.....	7.75	3.60	2.50	2.50	2.10	1.90	1.90	4.10	5.60
22	.....	7.35	3.80	2.50	2.50	2.10	1.90	1.90	3.80	6.90
23	.....	7.05	3.80	2.50	2.50	2.10	1.80	1.90	3.90	6.30
24	.....	6.65	3.80	2.50	2.50	2.10	1.80	1.90	3.60	6.30
25	10.00	6.20	3.80	2.50	2.50	2.00	1.80	1.90	3.40	6.50
26	9.25	5.85	3.70	2.70	2.40	2.00	1.90	1.90	3.40	7.10
27	8.10	5.70	3.60	2.60	2.40	2.00	1.90	1.90	3.30	6.90
28	7.35	5.65	3.50	2.60	2.40	2.30	1.80	1.80	3.20	6.40
29	7.30	5.35	3.30	2.90	2.40	2.20	1.90	1.90	3.10	5.80
30	7.55	5.10	3.20	3.20	2.40	3.50	2.10	1.90	3.10	5.00
31	7.45	.....	3.20	.....	2.30	3.20	.....	1.90	.....	.....

WEST BRANCH OF SUSQUEHANNA RIVER AT ALLENWOOD, PENNSYLVANIA.

The West Branch of Susquehanna River rises in Cambria County, Pennsylvania, and flows in a general northeasterly direction, meeting the North Branch on the western border of Northumberland County and forming Susquehanna River.

Observations of height of water on the West Branch have been made by the Weather Bureau at Lockhaven, Pennsylvania, 47 miles above Allenwood. The drainage area is given as 3,740 square miles, and the width of river 1,125 feet. The gage is in two sections. The lower section is painted on the side wall of the canal lock, and the upper is on the highway bridge over the river. The elevation of the zero is 555.7 feet. The highest water was 18 feet, on June 1, 1889, and the danger line is at ten feet.

Below the junction of the North and West Branches of Susquehanna River observations have been made of height of water by the Weather Bureau at Selins Grove, 45 miles above Harrisburg. The drainage area is given as 17,600 square miles. The river at this point is about 1 mile wide, including an island 400 feet wide. The gage is on the west abutment of a railroad bridge.

A gaging station was established on the West Branch by E. G. Paul on March 25, 1899, at Allenwood, Pennsylvania, 20 miles above the junction with the North Branch. Measurements are made from the

ublic highway bridge, one-fourth of a mile east of the railroad sta-on at Allenwood. The wire gage is 42.15 feet from zero to the end f the weight, and is referred to a pine-board scale fastened to iron-ork of the bridge and divided into feet and tenths. The initial oint of soundings is at the end of the iron guard rail on the right ank. The channel is straight for one-half a mile above and below ie station. The current is sluggish, but unobstructed. The banks re low and subject to overflow at time of high water. The bed of ie stream is rocky and constant. The observer is Frank L. Allen, farmer living 200 feet from the gage. The following measurements ere made by E. G. Paul during 1899:

March 24, gage height, 4.90 feet; discharge, 32,031 second-feet.
June 8, gage height, 3.00 feet; discharge, 3,988 second-feet.
July 28, gage height, 2.05 feet; discharge, 1,360 second-feet.
September 15, gage height, 1.90 feet; discharge, 1,234 second-feet.
October 17, gage height, 1.70 feet; discharge, 842 second-feet.

aily gage height, in feet, of West Branch of Susquehanna River at Allenwood, Pennsylvania, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	6.70	3.80	3.50	2.90	2.00	2.70	2.00	2.20	2.90
2	.....	6.30	3.80	3.50	2.70	2.00	2.70	2.00	3.60	2.80
3	.....	5.80	3.80	3.40	2.50	2.00	2.70	1.90	4.20	2.70
4	.....	5.35	3.90	3.40	2.50	1.80	2.50	1.90	5.20	2.70
5	.....	5.05	3.80	3.30	2.40	1.70	2.40	1.90	4.60	2.70
6	.....	4.90	3.60	3.20	2.40	1.70	2.30	1.90	4.00	2.60
7	.....	4.80	3.50	3.00	2.30	1.70	2.10	1.90	3.40	2.60
8	.....	6.45	3.30	3.00	2.40	1.70	2.00	1.90	3.20	2.60
9	.....	7.80	3.40	2.90	2.20	1.70	2.00	1.90	3.00	2.60
10	.....	7.40	3.50	2.90	2.00	1.70	2.00	1.80	3.00	2.60
11	.....	6.60	3.60	2.70	2.10	1.70	1.90	1.80	3.00	2.60
12	.....	6.20	3.70	2.60	2.30	1.70	1.90	1.80	3.20	5.30
13	.....	6.50	3.50	2.60	2.20	1.90	1.90	1.70	3.30	8.40
14	.....	7.00	3.40	2.60	2.20	1.90	1.90	1.70	3.40	7.40
15	.....	6.90	3.30	2.50	2.30	1.90	1.90	1.70	3.50	6.50
16	.....	6.80	3.20	2.50	2.20	1.90	1.90	1.70	3.60	5.80
17	.....	6.40	3.40	2.50	2.30	1.90	1.90	1.70	3.80	5.10
18	.....	5.60	3.80	2.40	2.40	1.90	1.90	1.70	3.90	4.90
19	.....	5.40	7.40	2.40	2.60	1.80	1.90	1.70	4.10	4.80
20	.....	5.00	6.50	2.40	2.80	1.70	1.90	1.70	4.30	4.70
21	.....	4.80	5.75	2.40	3.00	1.70	1.90	1.60	4.10	4.30
22	.....	4.70	5.15	2.30	2.70	1.70	1.90	1.60	4.00	4.20
23	4.90	4.50	4.70	2.20	2.50	1.70	1.90	1.60	3.90	4.20
24	4.90	4.40	4.35	2.20	2.30	1.60	1.90	1.60	3.80	5.15
25	4.60	4.30	4.00	2.80	2.20	1.60	1.90	1.60	3.70	7.25
26	4.20	4.30	3.80	2.50	2.20	1.60	1.90	1.60	3.60	5.60
27	4.30	4.30	3.60	2.60	2.10	1.70	2.00	1.60	3.40	5.00
28	6.20	4.20	3.50	2.70	2.00	3.70	2.00	1.60	3.30	4.50
29	6.70	4.30	3.40	2.70	1.90	3.00	2.00	1.60	3.20	4.10
30	7.80	4.10	3.40	2.80	1.80	2.60	2.00	1.60	3.10	3.60
31	7.35	.....	3.50	.....	2.00	2.60	.....	1.60	.....	.....

JUNIATA RIVER AT NEWPORT, PENNSYLVANIA.

Juniata River rises in Center County, Pennsylvania, and flows in general southeasterly direction into Susquehanna River 15 miles bove Harrisburg. Its drainage area is mountainous and for the iost part covered with forest growth. The station was established t Newport, about 15 miles above its junction with the Susquehanna,

on March 21, 1899, by E. G. Paul. It is at the covered wagon bridge, 600 feet east of the public square, Newport, Pennsylvania. The wire gage is 39.54 feet long from the end of the weight to the index. A scale board is nailed to the bridge timbers inside of the structure and is divided into feet and tenths. The initial point of soundings is at the end of the woodwork of the bridge on the right bank. The channel is straight for half a mile above and below the station. The current is swift and unobstructed. The banks are high and not subject to overflow. The bed of the stream is rocky and the section constant. The observer is A. R. Bortel, a laborer living in Newport, Pennsylvania, about 800 feet from the gage. The following measurements were made by E. G. Paul during 1899:

March 21, gage height, 6.60 feet; discharge, 12,094 second-feet.
June 9, gage height, 2.30 feet; discharge, 1,903 second-feet.
July 31, gage height, 2.90 feet; discharge, 602 second-feet.
September 14, gage height, 4.55 feet; discharge, 4,825 second-feet.
October 18, gage height, 2.90 feet; discharge, 829 second-feet.

Daily gage height, in feet, of Juniata River at Newport, Pennsylvania, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	7.00	3.40	3.11	2.70	3.00	3.50	3.20	2.70	3.30
2	.....	6.10	3.40	3.60	2.70	3.00	3.50	3.10	4.00	3.30
3	.....	5.50	3.60	3.50	2.60	3.00	3.40	3.10	4.00	3.30
4	.....	5.10	3.70	3.40	2.50	3.00	3.40	3.10	4.60	3.30
5	.....	4.90	3.50	3.30	3.00	3.00	3.20	3.00	4.20	3.30
6	.....	4.50	3.40	3.40	3.00	3.00	3.30	3.00	3.90	3.20
7	.....	4.30	3.40	3.30	3.00	3.30	3.30	3.00	3.70	3.10
8	.....	5.60	3.40	3.20	3.00	3.50	3.30	3.00	3.50	3.10
9	.....	7.80	3.60	3.20	3.10	3.30	3.30	2.90	3.50	3.10
10	.....	6.90	3.60	2.80	3.30	3.20	3.30	2.90	3.40	3.10
11	.....	5.80	4.00	2.80	3.30	3.10	3.30	2.90	3.30	3.10
12	.....	5.50	4.10	2.80	3.30	3.10	3.40	2.90	3.30	3.70
13	.....	5.10	4.00	2.80	3.10	3.40	4.80	2.90	3.30	4.80
14	.....	4.90	3.80	2.70	3.10	3.10	4.80	2.90	3.20	5.50
15	.....	4.80	3.80	2.70	3.10	3.10	3.80	2.90	3.20	5.10
16	.....	4.70	3.60	2.70	3.00	3.00	3.50	2.90	3.20	4.80
17	.....	5.50	3.70	2.70	2.90	3.00	3.30	2.90	3.20	4.30
18	.....	4.40	4.10	2.70	2.90	3.00	3.10	2.90	3.10	4.00
19	.....	4.30	8.00	2.60	2.90	3.00	3.10	2.90	3.10	4.00
20	.....	4.10	7.30	2.60	3.00	3.10	3.10	2.90	3.10	3.70
21	6.50	4.00	7.60	2.60	3.00	3.00	3.10	2.90	3.10	3.70
22	6.00	3.90	5.10	2.60	3.00	3.00	3.10	2.90	3.10	5.00
23	5.70	3.80	4.70	2.50	3.00	2.90	3.10	2.80	3.10	5.00
24	6.00	3.80	4.40	2.50	3.00	2.90	3.10	2.80	3.40	5.00
25	5.50	3.70	4.00	2.50	3.00	2.90	3.10	2.80	4.00	5.80
26	5.20	3.60	3.70	2.50	3.00	2.90	3.10	2.80	4.00	5.50
27	5.10	3.60	3.70	2.50	2.80	2.90	3.10	2.80	3.80	4.50
28	5.10	3.60	3.70	2.60	2.90	4.40	3.20	2.80	3.60	4.30
29	8.80	3.50	3.70	2.70	2.90	4.10	3.30	2.80	3.50	4.10
30	10.30	3.40	4.10	2.70	2.90	5.00	3.30	2.70	3.40	4.10
31	8.30	.....	3.11	.....	2.90	4.40	.....	2.70	.....	4.10

SUSQUEHANNA RIVER AT HARRISBURG, PENNSYLVANIA.

Observations of the height of water in the Susquehanna River have been made for several years at the pump house of the waterworks located in the western part of the city of Harrisburg, Pennsylvania, this being about 55 miles below the junction of the north and west branches. A float is located in the pump well connected with the

river, which indicates the height of water upon a painted scale. The datum is the low-water mark of 1804. Observations are made by the engineer, C. M. Nagle, each morning before starting the pumps. The record since 1890 has been furnished by E. Mather, president of the Harrisburg Water Company. Measurements of discharge are made from the open iron bridge on Second street. The initial point for soundings is the iron upright on the east end of the bridge. The stream is divided into two channels, with a large island between. The channel above and below the station is straight for about 2,500 feet, the banks high, and the current of moderate velocity. The first measurement was made on March 31, 1897. The results of measurement may be found as follows: 1897, Nineteenth Annual Report, Part IV, pages 122–127; 1898, Twentieth Annual Report, Part IV, page 109. The following measurements were made by E. G. Paul during 1899:

June 11, gage height, 1.75 feet; discharge, 11,746 second-feet.
July 29, gage height, 0.91 foot; discharge, 6,534 second-feet.
September 12, gage height, 0.75 foot; discharge, 5,404 second-feet.
October 25, gage height, 0.16 foot; discharge, 3,625 second-feet.

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pennsylvania, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.25	2.50	8.41	7.25	3.41	2.50	1.75	0.75	1.83	1.08	0.50	1.75
2	3.16	2.00	8.16	6.41	3.08	2.58	1.66	.75	1.50	.83	1.66	1.58
3	2.75	1.91	7.83	5.83	3.08	2.50	1.66	.75	1.25	.83	2.50	1.50
4	3.25	2.25	7.41	5.33	3.41	2.50	1.50	.75	1.08	.75	3.25	1.50
5	3.50	2.58	8.00	4.91	3.16	2.50	1.33	.75	1.08	.66	4.50	1.50
6	5.00	2.66	12.50	4.41	3.16	2.33	1.25	.91	1.00	.66	3.91	1.50
7	8.00	2.83	13.00	4.25	3.00	2.08	1.25	.75	.91	.58	3.75	1.50
8	6.83	2.41	11.41	4.75	2.75	1.91	1.16	.75	.91	.58	3.16	1.50
9	6.08	2.50	9.25	6.83	2.83	1.91	1.16	.83	.83	.58	2.83	1.50
10	5.41	2.41	7.66	8.75	2.66	1.91	1.16	.75	1.00	.66	2.50	1.50
11	4.58	2.41	6.50	8.41	2.75	1.75	1.41	.66	1.00	.58	2.25	1.50
12	4.00	4.41	5.75	7.75	2.75	1.66	1.25	.66	.75	.58	2.16	1.50
13	3.33	4.41	5.75	6.75	2.91	1.66	1.16	1.08	.83	.50	2.08	2.75
14	3.16	4.58	7.50	6.75	2.83	1.58	1.16	1.08	1.41	.50	2.00	5.50
15	3.33	4.58	8.41	8.00	2.58	1.50	1.16	1.25	1.25	.51	2.25	6.33
16	3.66	4.66	8.00	8.00	2.50	1.50	1.08	.91	.83	.41	2.41	6.00
17	4.83	4.83	7.41	7.83	2.50	1.41	1.00	.66	.75	.41	2.41	5.33
18	7.00	4.83	6.41	7.33	2.58	1.25	1.25	.66	.75	.41	2.41	4.58
19	6.33	4.91	4.33	6.83	3.75	1.25	1.25	.50	.58	.41	2.83	4.08
20	5.66	4.75	7.16	6.00	4.75	1.25	1.25	.50	.66	.33	3.00	3.75
21	4.91	4.91	8.50	5.41	5.16	1.25	1.25	.50	.75	.33	2.91	3.75
22	4.33	5.33	8.16	5.08	4.25	1.16	1.33	.50	.66	.33	2.58	3.83
23	4.25	7.50	7.50	4.91	3.91	1.08	1.33	.50	.66	.33	2.50	4.50
24	4.08	7.50	7.16	4.50	3.58	1.00	1.33	.50	.66	.16	2.25	4.25
25	4.16	7.16	7.41	4.41	3.16	1.41	1.16	.50	.66	.16	2.25	5.83
26	5.25	6.83	7.41	4.00	3.00	2.00	1.00	.41	.66	.25	2.25	6.75
27	4.50	7.33	6.83	3.91	2.91	1.66	1.00	.66	1.00	.33	2.16	5.25
28	3.83	9.00	6.33	3.75	2.66	1.50	1.00	4.00	1.33	.33	2.00	4.58
29	3.25	.....	6.83	3.66	2.50	1.50	.91	2.66	1.16	.41	2.00	3.83
30	3.00	.....	7.83	3.50	2.50	1.75	.83	2.50	1.08	.33	1.83	3.00
31	3.00	.....	8.08	.....	2.50	.....	.75	2.16	.....	.33	.....	2.25

OCTORARO CREEK AT ROWLANDSVILLE, MARYLAND.

This stream rises in Lancaster County, Pennsylvania, and flows in a southwesterly direction between Lancaster and Chester counties into Maryland, where it empties into the Susquehanna River about

five miles below the State line. This station was established November 21, 1896, at the wagon bridge in the village of Rowlandsville, Maryland. The situation is not a good one for making measurements, owing to an eddy along the left bank and the proximity of the mouth of a small tributary, which would cause cross currents in time of high water. The channel is straight, the current swift, the banks high and not subject to overflow. The observations and most of the gagings have been made by Hugh W. Caldwell, of Rowlandsville, Maryland. The record having been continued long enough to have determined the general flow of the stream the station was abandoned September 30, 1899. The following measurements were made by Hugh W. Caldwell during 1899:

Measurements of Octoraro Creek at Rowlandsville, Maryland.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec. feet.*	1899.	*Feet.*	*Sec. feet.*
January 24	6.40	1,505	June 28	3.50	185
February 4	4.40	531	June 29	4.06	367
March 15	5.00	600	July 15	3.50	219
March 31	4.80	722	July 28	3.40	186
April 15	4.30	507	August 7	3.50	171
April 21	4.20	470	August 11	5.20	1,044
May 8	4.30	558	August 19	3.40	141
May 29	4.60	413	August 26	3.60	236
June 5	3.80	231	September 25	5.60	1,113
June 16	3.70	189			

Daily gage height, in feet, of Octoraro Creek at Rowlandsville, Maryland, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	4.60	3.90	4.30	4.50	4.00	3.80	3.50	3.35	3.50
2	4.80	4.00	4.45	4.40	4.00	3.80	3.40	3.30	3.45
3	4.95	4.00	4.50	4.20	4.00	3.80	3.40	3.25	3.40
4	4.80	4.30	4.80	4.10	4.00	3.70	3.40	3.30	3.30
5	4.95	4.40	7.45	4.00	4.00	3.70	3.55	3.30	3.20
6	5.45	4.40	6.70	3.90	4.00	3.70	3.90	3.30	3.15
7	5.55	4.30	5.75	5.30	4.00	3.60	3.60	3.55	3.20
8	4.80	4.10	5.15	5.05	4.35	3.75	3.85	3.40	3.20
9	4.55	4.00	4.50	4.85	4.35	3.75	3.85	3.35	3.40
10	4.50	3.90	4.05	4.75	4.05	3.90	3.55	5.30	3.40
11	4.50	3.85	3.80	4.65	4.20	3.75	3.50	3.55	3.45
12	4.30	4.20	3.75	4.30	4.25	3.70	3.45	3.45	3.70
13	4.75	4.85	6.30	4.30	4.05	3.70	3.45	3.45	3.50
14	4.40	5.00	4.60	4.30	4.15	3.70	3.45	3.40	3.40
15	4.30	4.70	5.15	4.30	4.00	3.70	3.50	3.40	3.40
16	4.25	4.65	4.70	4.20	4.05	3.70	3.50	3.40	3.30
17	4.15	7.20	4.40	4.25	4.00	3.65	3.40	3.40	3.30
18	4.00	6.90	4.30	4.20	4.25	3.60	3.55	3.40	3.30
19	3.90	6.80	4.25	4.20	4.05	3.60	3.45	3.40	3.35
20	3.85	6.45	4.20	4.20	4.00	3.60	3.40	3.30	3.85
21	3.70	6.15	4.05	4.20	4.00	3.65	3.35	3.25	3.70
22	3.70	5.75	4.00	4.20	3.95	3.60	3.35	3.40	3.60
23	3.60	5.50	4.00	4.20	3.90	3.50	3.30	3.35	3.35
24	6.30	5.25	3.90	4.10	3.90	3.50	3.35	3.30	3.30
25	6.10	5.05	5.20	4.10	3.85	3.65	3.30	3.30	3.50
26	5.60	5.55	4.70	4.10	3.80	3.65	3.65	3.30	6.30
27	4.90	5.05	4.50	4.00	3.80	3.50	3.65	3.50	4.95
28	4.45	4.55	6.95	4.00	3.80	3.50	3.40	3.55	4.65
29	4.25	.....	5.60	4.00	3.80	3.80	3.40	3.50	4.00
30	4.10	.....	5.00	4.00	3.85	3.60	3.40	3.50	4.15
31	4.05	.....	4.80	.....	3.80	.....	3.40	3.50	.....

Discontinued September 30, 1899.

PATAPSCO RIVER AT WOODSTOCK, MARYLAND.

ver rises in the north-central part of Maryland, flows in a erly direction between Baltimore and Howard counties, and into Chesapeake Bay. Its watershed is a hilly country nder cultivation. A station was established at Woodstock ;, 1896, by E. G. Paul. The drainage area is 251 square . is partly shown on the Ellicott and Frederick sheets of the hic atlas. Measurements are made from the county bridge on from Woodstock to Granite, Maryland, 1½ miles below the with the North Branch, as shown on the Ellicott atlas sheet. ' is a board graduated to feet and tenths with small nails, ned to the floor timber of the bridge. The bench mark is a tates Geological Survey standard copper bolt, set in the face taining wall of the entrance to the college grounds at the d of the bridge. It is 22.06 feet above gage datum. The ıs repaired on January 20–25, 1899, and the gage destroyed. A was established on January 30, 1899, and referred to the same ırk. The channel is rough and rocky. The banks are high subject to overflow. At a time of extreme high water the s liable to changes. The observer is David Donovan, a store- Woodstock, Maryland. The three following measurements le by E. G. Paul during 1899: January 30, gage height 4.30 harge 431 second-feet; May 22, gage height 4.20 feet, dis- 0 second-feet; September 6, gage height 3.60 feet, discharge d-feet.

e height, in feet, of Patapsco River at Woodstock, Maryland, for 1899.

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
(a)	3.80	4.85	4.65	4.20	3.95	3.75	3.65	3.60	3.55	3.60	3.70
(a)	5.10	4.90	4.50	4.15	4.15	3.60	4.30	3.70	3.55	3.75	3.60
(a)	5.00	4.70	4.45	4.20	3.95	3.70	4.10	3.80	3.55	3.70	3.20
(a)	4.90	4.75	4.35	4.30	3.95	3.75	3.85	3.65	3.40	3.60	3.60
(a)	4.90	8.50	4.40	4.15	3.95	4.25	3.85	3.60	3.60	3.70	3.60
(a)	5.20	6.70	4.30	4.25	3.95	4.00	3.85	3.45	3.80	3.60	3.65
(a)	5.35	5.20	4.60	4.25	3.80	3.90	3.90	3.40	3.75	3.70	3.55
(a)	Ice.	4.90	5.90	4.35	3.85	3.90	3.75	3.75	3.60	3.70	3.60
(a)	Ice.	4.70	4.65	4.45	3.95	3.90	3.75	3.45	3.70	3.70	3.65
(a)	Ice.	4.70	4.65	4.25	4.20	3.95	3.70	3.70	3.70	3.70	3.75
(a)	Ice.	4.75	4.45	4.15	4.20	3.75	3.55	3.55	3.65	3.70	3.75
(a)	Ice.	4.75	4.50	4.35	4.15	3.65	3.60	3.55	3.55	3.50	4.05
(a)	Ice.	4.65	4.20	4.25	4.10	3.80	3.65	3.55	3.45	3.50	3.90
(a)	Ice.	4.55	4.35	4.25	4.05	4.05	3.85	3.50	3.50	3.75	3.80
(a)	Ice.	4.85	4.40	4.20	3.95	3.80	3.35	3.50	3.70	3.65	3.65
(a)	Ice.	4.80	4.45	4.15	4.00	3.80	3.80	3.45	3.65	3.60	3.60
(a)	Ice.	4.60	4.45	4.25	4.10	4.15	3.65	3.35	3.65	3.70	3.30
(a)	Ice.	4.75	4.40	4.85	4.00	4.15	3.75	3.45	3.65	3.70	3.85
(a)	Ice.	5.30	4.30	4.50	3.95	3.95	3.65	3.45	3.60	3.60	3.95
(a)	Ice.	4.85	4.30	4.25	3.75	3.80	3.65	3.35	3.70	3.80	3.95
(a)	6.20	4.70	4.30	4.20	3.85	3.75	3.65	4.00	3.55	3.75	3.85
(a)	5.75	5.00	4.30	4.20	4.00	3.75	3.60	3.45	3.40	3.75	3.80
(a)	5.40	4.90	4.25	4.25	3.85	3.70	3.55	3.40	3.40	3.70	3.20
(a)	4.95	4.50	4.25	4.20	3.80	3.90	3.50	3.45	3.55	3.65	3.30
(a)	5.15	4.40	4.30	4.10	3.80	3.85	3.50	3.55	3.55	3.70	4.40
(a)	4.80	4.40	4.25	4.05	3.85	3.90	3.60	5.90	3.60	3.70	3.95
(a)	6.15	4.40	4.30	4.00	4.00	3.85	3.65	4.25	3.65	3.65	3.80
(a)	5.05	5.30	4.25	4.10	3.85	3.75	3.90	4.00	3.60	3.75	3.85
(a)	.....	4.85	4.20	4.00	3.75	3.75	3.90	3.60	3.25	3.70	4.15
4.30	.....	4.75	4.20	4.00	3.85	3.50	3.55	3.55	3.60	3.70	4.60
3.90	.....	4.65	.....	4.00	.....	3.80	3.65	.....	3.60	.....	.....

a Gage out; no readings.

NORTH BRANCH OF POTOMAC RIVER AT PIEDMONT, WEST VIRGINIA.

This stream rises in the western part of West Virginia and flows in a northeasterly direction, forming the boundary between Maryland and West Virginia. At a point about 15 miles below Cumberland it is joined by the South Branch, forming the Potomac River. The drainage area is mapped on Piedmont, St. George, Accident, Grantsville, and Frostburg atlas sheets. Systematic measurements of discharge have been made at Piedmont, West Virginia. This station, established June 27, 1899, by E. G. Paul, is located at the iron highway bridge connecting Luke, Maryland, with Piedmont, West Virginia. The wire gage is 38.87 feet from index to end of weight, and is referred to a scale board 14 feet long, attached to the bridge 90 feet from the first pier, and is divided into feet and tenths. The channel is straight for an eighth of a mile above and below the station. The current is swift and unobstructed. The right bank is high and rocky, but the left bank is low and liable to overflow. The bed of the stream is rocky and permanent in section. The observer is Charles W. Beck, a bookkeeper at Piedmont, West Virginia. A measurement was made by E. G. Paul on June 27, 1899, at a gage height of 3.00 feet, when the discharge was 350 second-feet.

Daily gage height, in feet, of North Branch of Potomac River at Piedmont, West Virginia, for 1899.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.15	2.50	2.20	2.20	3.75	2.60
2	.....	2.90	2.35	2.20	2.20	3.90	2.60
3	.....	2.80	2.25	2.10	2.15	3.05	2.60
4	.....	2.70	2.40	2.00	2.10	2.80	2.55
5	.....	2.65	2.40	2.30	2.10	2.70	2.50
6	.....	2.70	2.40	2.20	2.10	2.55	2.40
7	.....	2.80	2.55	2.15	2.20	2.50	2.40
8	.....	2.70	2.30	2.10	2.10	2.40	2.40
9	.....	2.70	2.30	2.20	2.15	2.40	2.35
10	.....	2.70	2.25	2.30	2.10	2.40	2.40
11	.....	2.65	2.10	2.95	2.10	2.40	2.50
12	.....	2.50	2.15	3.40	2.20	2.40	5.20
13	.....	2.40	2.10	2.75	2.10	2.30	4.60
14	.....	2.85	2.10	2.45	2.10	2.30	3.75
15	.....	2.85	2.10	2.35	2.00	2.30	3.60
16	.....	2.50	2.00	2.30	2.20	2.30	3.35
17	.....	2.70	2.00	2.30	2.10	2.30	3.05
18	.....	2.90	2.00	2.15	2.10	2.20	3.15
19	.....	2.65	2.00	2.10	2.10	2.40	3.20
20	.....	2.50	2.00	2.45	2.10	3.35	3.70
21	.....	2.35	2.00	2.90	2.10	3.00	3.30
22	.....	.....	1.95	2.65	2.00	2.80	3.20
23	.....	2.30	1.90	2.40	2.00	2.85	3.10
24	.....	2.30	1.90	2.40	2.10	3.30	3.00
25	.....	2.30	1.90	2.25	2.10	3.20	3.00
26	.....	2.20	1.90	2.20	2.10	3.00	2.90
27	3.00	2.15	2.10	2.30	2.10	2.80	2.80
28	2.90	2.50	3.00	2.55	2.10	2.80	2.80
29	3.85	2.35	2.90	2.40	2.20	2.70	2.80
30	3.50	2.30	2.55	2.25	2.15	2.60	2.80
31	.....	2.45	2.35	.....	2.15	.....	2.70

OUTH BRANCH OF POTOMAC RIVER AT SPRINGFIELD, WEST VIRGINIA.

This stream rises in Highland County, West Virginia, and flows n a northeasterly direction, joining the North Branch of Potomac tiver about 15 miles below Cumberland, Maryland, forming Potomac tiver. The drainage area of the South Branch consists of long, arrow, mountain valleys, sparsely settled and little cultivated, being or the greater part covered with timber. The region being free rom manufacturing industries and mining operations, no pollution f the waters occurs. The drainage area is mapped on the follow-ng atlas sheets: Romney, Piedmont, Beverly, Franklin, Woodstock, taunton, and Monterey. A gaging station was established at the ailroad bridge, 2 miles south of Springfield, West Virginia, in April, 894, by Cyrus C. Babb, but was discontinued in 1896 for want of an bserver. The present station, established June 26, 1899, by E. G. 'aul, is located on the iron highway bridge, one-fourth of a mile rom Graces Station and 1 mile from Springfield. The wire gage s 39.4 feet from the zero to the extreme end of the weight, and is eferred to a scale graduated to feet and tenths, on the guard rail on he upper side of the bridge 80 feet from the abutment on the left ank. The channel of the stream at this point is curved and the urrent too sluggish to make satisfactory discharge measurements, nd they are, therefore, made from the railroad bridge over the stream mile above. The observer is John E. Grace, of Springfield, West 'irginia. A measurement was made by E. G. Paul, June 26, 1899, at gage height of 4.00 feet, when the discharge was 617 second-feet.

Daily gage height, in feet, of South Branch of Potomac River at Springfield, West Virginia, for 1899.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.20	3.40	3.40	3.40	4.60	4.60
2	.....	3.70	3.60	3.40	3.40	4.80	4.10
3	.....	3.70	3.50	3.50	3.40	4.80	4.00
4	.....	3.70	3.40	3.60	3.30	4.80	4.00
5	.....	3.60	3.20	3.60	3.30	4.60	3.80
6	.....	3.60	3.20	3.60	3.20	4.60	3.70
7	.....	3.60	3.20	3.50	3.20	4.50	3.70
8	.....	3.70	3.20	3.50	3.20	4.40	3.50
9	.....	4.20	3.10	3.50	3.20	4.20	3.40
10	.....	3.90	3.10	3.50	3.20	4.10	3.80
11	.....	3.80	3.10	3.40	3.10	4.10	4.00
12	.....	3.60	3.00	3.40	3.10	4.00	5.80
13	.....	3.40	3.00	3.40	3.10	4.00	5.60
14	.....	3.20	3.10	3.40	3.20	4.00	5.60
15	.....	3.10	3.20	3.50	3.20	3.90	5.40
16	.....	3.00	3.20	3.50	3.20	3.80	5.60
17	.....	2.90	3.10	3.50	3.20	3.70	5.60
18	.....	3.00	3.10	3.40	3.20	3.60	5.50
19	.....	3.40	3.00	3.40	3.10	3.60	5.50
20	.....	3.20	3.00	3.40	3.10	3.90	5.40
21	.....	3.20	3.10	3.30	3.10	4.90	5.40
22	.....	3.20	3.20	3.30	3.10	5.90	5.40
23	.....	3.40	3.20	3.20	3.00	5.80	5.00
24	.....	3.50	3.30	3.10	3.00	5.60	4.00
25	.....	3.50	3.30	3.10	3.20	5.60	Ice.
26	4.00	3.40	3.20	3.00	3.40	5.40	Ice.
27	4.20	3.40	3.20	3.00	3.50	5.20	Ice.
28	3.90	3.20	3.10	3.20	3.50	4.80	Ice.
29	4.10	3.20	3.10	3.30	3.80	4.70	Ice.
30	3.40	3.20	3.20	3.40	4.20	4.60	Ice.
31	.....	3.20	3.20	.....	4.40	.....	Ice.

ANTIETAM CREEK AT SHARPSBURG, MARYLAND.

This stream rises in the western part of Maryland and flows in a southerly direction, entering the Potomac 10 miles above Harpers Ferry. Its drainage area is mostly of a hilly character and largely cultivated. A station was established at Myers Mill, 1 mile east of Sharpsburg, Maryland, on the road to Keedysville, Maryland, on June 24, 1897, by Arthur P. Davis. The measurements are made from a three-fourths inch iron cable with 85-foot span, supported by large trees on either side of the stream. The gage is a post driven into the gravel of the stream bed and bolted to an overhanging tree. The initial point for soundings is on the left bank. The channel both above and below the station is straight for 300 feet. The right bank is low and liable to overflow. The left bank is high and rocky. The current is of moderate velocity and the flow unobstructed. The results of measurements may be found as follows: 1897, Nineteenth Annual Report, Part IV, page 149; 1898, Twentieth Annual Report, Part IV, page 122. The following measurements were made by E. G. Paul during 1899: January 27, gage height 2.80 feet, discharge 495 second-feet; May 20, gage height 2.60 feet, discharge 418 second-feet; September 5, gage height 1.80 feet, discharge 118 second-feet.

Daily gage height, in feet, of Antietam Creek at Sharpsburg, Maryland, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	2.70	4.75	3.40	2.40	2.40	2.10	1.70	1.80	1.80	2.40	1.60
2	2.70	2.60	4.20	3.30	2.45	3.75	1.90	1.60	1.80	1.80	2.25	1.60
3	2.60	2.60	4.10	3.20	2.90	2.60	2.00	2.55	1.70	1.70	2.00	1.60
4	2.70	2.60	3.85	3.20	2.50	2.60	1.85	1.90	2.00	1.60	1.80	1.50
5	3.00	2.80	4.80	3.10	2.50	2.40	1.90	1.80	1.80	1.60	1.80	1.60
6	3.40	2.80	4.40	3.00	2.50	2.40	1.80	1.70	1.80	1.50	1.90	1.50
7	3.55	2.50	4.05	2.90	2.40	2.30	2.00	1.90	1.70	1.50	1.80	1.50
8	3.20	2.40	3.90	3.25	2.55	2.30	1.90	1.70	1.70	1.50	1.50	1.60
9	3.00	2.60	3.60	3.10	2.70	2.45	1.90	1.70	1.85	1.70	1.60	1.60
10	3.00	2.80	3.50	3.00	2.55	2.70	2.00	1.80	1.60	1.60	1.70	1.50
11	2.90	2.60	3.50	2.90	2.50	2.65	1.90	1.80	2.30	1.50	1.60	1.50
12	2.80	2.80	3.40	2.80	2.50	2.40	1.80	2.35	2.10	1.50	1.70	1.60
13	2.90	2.80	3.30	2.80	2.50	2.40	2.15	1.90	1.85	1.50	1.70	1.60
14	3.00	2.80	3.20	2.80	2.40	2.35	2.00	2.00	1.80	1.50	1.60	1.70
15	3.00	2.90	3.20	2.80	2.30	2.30	1.90	1.90	1.70	1.40	1.60	1.80
16	3.00	2.90	3.50	2.80	2.40	2.30	1.85	1.80	1.60	1.80	1.60	1.80
17	3.00	2.80	3.20	2.70	2.20	2.30	1.95	1.90	1.60	1.70	1.80	1.70
18	3.00	2.90	3.20	2.70	3.15	2.20	1.80	1.80	1.70	1.60	1.70	1.70
19	2.90	2.90	3.70	2.70	2.80	2.25	1.85	1.80	2.00	1.60	1.70	1.60
20	2.80	2.80	3.75	2.60	2.60	2.20	1.80	1.60	1.90	1.60	1.70	1.60
21	2.80	3.20	3.40	2.60	2.50	2.20	1.80	1.80	1.90	1.60	1.70	1.70
22	2.80	4.30	3.40	2.60	2.50	2.10	1.80	1.70	1.80	1.60	1.80	1.60
23	2.80	4.10	3.50	2.50	2.50	2.00	2.05	1.80	1.80	1.70	1.80	1.60
24	2.80	3.70	3.40	2.40	2.40	2.10	1.90	1.70	1.70	1.60	1.70	1.85
25	3.25	3.50	3.30	2.50	2.30	2.05	1.70	1.65	1.90	1.60	1.60	2.65
26	2.90	4.50	3.20	2.45	2.30	2.20	1.75	1.70	1.90	1.50	1.60	1.90
27	2.90	5.40	3.00	2.50	2.30	2.10	1.70	3.45	1.80	1.50	1.70	2.00
28	2.80	5.15	3.50	2.50	2.30	2.15	1.60	2.80	1.80	1.50	1.60	1.90
29	2.80	.....	3.90	2.50	2.20	2.10	1.60	2.30	1.90	1.50	1.70	1.80
30	2.70	.....	3.70	2.40	2.45	2.20	1.60	2.00	1.90	1.60	1.70	1.60
31	2.70	.....	3.50	.....	2.40	.....	1.80	1.90	.....	1.60	.....	.....

NORTH AND SOUTH RIVERS AT PORT REPUBLIC, VIRGINIA.

North and South rivers rise in Rockbridge County, Virginia, and flow in a southeasterly direction, joining at Port Republic to form the

ıth Fork of the Shenandoah River. The drainage areas of these › rivers are entirely mapped on Franklin, Harrisonburg, Staunton, ckingham, and Lexington sheets. Systematic measurements are de on the North and South rivers at Port Republic. These sta- ıs, described in the Eighteenth Annual Report, Part IV, page 25, ·e established in August, 1895, by D. C. Humphreys.

'he gage for the North River is located on the county highway ıdge at Port Republic, Virginia, 500 feet above the mouth of South ·er. A painted rod is fastened to the third panel of the first span the lower side of the bridge. It is nailed to the wooden uprights l fastened by wire to the diagonals. Bench mark No. 1, the lower l of the third floor beam from the right bank, is 24.97 feet above o of the gage. Bench mark No. 2, the bridge seat on lower end of ht bank abutment, is 24.60 feet above the datum of the gage.

'he gage for South River is located on the county iron bridge just t of the town, 300 feet above the mouth of North River. The ıduations of the rod are marked by tacks driven into the rail on the per side of the bridge at the fourth panel, the zero being 1 foot ·m the edge of the pulley. Bench mark No. 1, the top of the third or beam from right bank upper side of bridge, is 22.52 feet above ge datum. The zero of North River gage is 2.56 feet below the zero South River gage. All gagings of South River include the dis- arge of mill race. The observer at both gages is T. S. Davis, store- eper, Port Republic, Virginia. In September, 1898, a new bridge ıs built to replace the old one, and the stations were soon afterwards andoned (April 1, 1899), as measurements were made lower down, at ·ont Royal. Records of measurements may be found as follows: 95–96, Eighteenth Annual Report, Part IV, pages 25, 26. One ·asurement was made at each station by E. G. Paul in 1899, as fol- ·s: North River, March 11, gage height, 4.80 feet; discharge, 3,423 ·ond-feet. South River, March 11, gage height, 3.70 feet; discharge, 592 second-feet.

)aily gage height, in feet, of North River at Port Republic, Virginia, for 1899.

Day.	Jan.	Feb	Mar.	Apr.	Day.	Jan.	Feb.	Mar.	Apr.
1	2.75	2.30	7.10	*a* 3.00	17	2.70	3.00	4.00	.....
2	2.75	2.30	5.50	.....	18	2.70	3.00	3.70	.....
3	2.70	2.30	5.00	.....	19	2.60	3.40	4.00	.....
4	2.65	2.30	7.40	.....	20	2.60	4.00	4.30	.....
5	2.65	2.30	14.00	.....	21	2.60	5.50	3.90	.....
6	5.40	2.30	8.90	.....	22	2.60	7.00	3.60	.....
7	6.70	2.30	7.50	.....	23	2.60	7.60	3.40	.....
8	5.00	2.40	5.80	.....	24	2.60	6.00	3.20	.....
9	4.00	2.40	4.80	.....	25	2.60	4.90	3.10	.....
10	3.60	2.50	5.30	.....	26	2.60	4.90	3.10	.....
11	3.40	2.50	4.80	.....	27	2.60	6.00	3.00	.....
12	3.20	2.50	4.60	.....	28	2.60	9.00	3.00	.....
13	3.00	2.50	4.00	.....	29	2.50	.....	3.00	.....
14	2.90	2.70	3.80	.....	30	2.50	.....	3.00	.....
15	2.80	2.80	4.50	.....	31	2.40	.....	3.00	.....
16	2.80	3.00	4.20	.....					

a Discontinued April 1.

Daily gage height, in feet, of South River at Port Republic, Virginia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	Day.	Jan.	Feb.	Mar.	Apr.
1	2.50	2.10	4.00	a 2.50	17	2.50	2.60	3.20	.....
2	2.50	2.10	3.60	.....	18	2.40	2.60	2.90	.....
3	2.40	2.10	3.50	.....	19	2.20	2.80	3.20	.....
4	2.30	2.10	5.10	.....	20	2.20	3.00	2.70	.....
5	2.30	2.10	12.00	.....	21	2.20	3.50	3.50	.....
6	3.40	2.10	6.70	.....	22	2.20	5.00	3.20	.....
7	5.00	2.10	5.50	.....	23	2.20	5.60	3.10	.....
8	3.80	2.20	4.00	.....	24	2.20	4.10	2.90	.....
9	3.60	2.20	3.60	.....	25	2.20	3.50	2.80	.....
10	3.00	2.30	3.90	.....	26	2.20	4.40	2.80	.....
11	2.90	2.30	3.70	.....	27	2.20	6.50	2.80	.....
12	2.75	2.30	3.60	.....	28	2.20	5.30	2.70	.....
13	2.60	2.30	3.40	.....	29	2.20	.....	2.70	.....
14	2.60	2.40	3.30	.....	30	2.20	.....	2.60	.....
15	2.60	2.50	3.40	.....	31	2.10	.....	2.50	.....
16	2.60	2.60	3.30	.....					

a Discontinued April 1.

NORTH BRANCH OF SHENANDOAH RIVER AT RIVERTON, VIRGINIA.

This stream rises in Rockingham County, Virginia, and flows in a northeasterly direction, joining with the South Branch of the Shenandoah at Riverton, Virginia. The station was established at Riverton by A. P. Davis June 26, 1899. Measurements were made from an iron-wire cable, about 260 feet in span, stretched across the river on timber supports, 2 miles northwest of Riverton. The station is most easily reached by a private conveyance from Front Royal, Virginia. The gage is a vertical timber, graduated to feet and tenths, bolted to a large sycamore tree on the right bank of the stream. The initial point of soundings is on the right bank. The channel is straight above and below the station for about 600 feet. The banks are low and liable to overflow in time of high water. Bed of stream is rocky and constant. The observer is O. Menefee, a farmer, Riverton, Virginia. Two observations of river height are taken daily. Two measurements were made by E. G. Paul during 1899, both on September 2, with a gage height of 2.85 feet in each case. One measurement was made at the cross section at the point where the cable spans the stream, giving a discharge of 270 second-feet. The other measurement was made by wading, at a better cross section, 300 feet below the regular station, giving a discharge of 287 second-feet.

ly gage height, in feet, of North Branch of Shenandoah River at Riverton, Virginia, for 1899.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.80	2.68	2.88	2.70	3.20	.....
2	.....	2.80	2.68	2.88	2.68	2.95	.....
3	.....	2.78	2.68	2.95	2.60	2.95	2.65
4	.....	2.80	2.70	2.85	2.65	2.95	2.65
5	.....	2.73	2.65	2.73	2.70	2.85	2.63
6	.....	2.73	3.00	2.73	2.68	2.80	2.60
7	.....	2.80	2.95	2.73	2.65	2.80	2.63
8	.....	2.80	2.95	2.70	2.65	2.80	2.65
9	.....	2.80	2.83	2.70	2.68	2.80	2.60
10	.....	2.80	2.80	2.70	2.70	2.80	2.63
11	.....	2.80	2.73	2.70	2.70	2.78	2.65
12	.....	2.78	2.70	2.73	2.70	2.75	2.68
13	.....	2.75	2.70	2.73	2.70	2.73	2.80
14	.....	2.75	2.73	2.70	2.70	2.70	2.85
15	.....	2.70	2.70	2.70	2.70	2.70	2.90
16	.....	2.68	2.78	2.68	2.65	2.70	2.90
17	.....	2.68	2.78	2.70	2.65	2.70	2.90
18	.....	2.78	2.78	2.68	2.70	2.70	2.90
19	.....	2.75	2.70	2.60	2.68	2.70	2.88
20	.....	2.70	2.65	2.80	2.70	2.70	2.80
21	.....	2.68	2.63	2.80	2.65	2.70	2.80
22	.....	2.68	2.63	2.80	2.65	2.70	2.80
23	.....	2.65	2.68	2.80	2.65	2.70	2.80
24	.....	2.58	2.65	2.80	2.65	2.70	2.80
25	.....	2.63	2.63	2.80	2.70	2.70	2.83
26	2.85	2.70	2.65	2.80	2.70	.....	2.88
27	2.88	2.68	2.63	2.78	2.70	.....	3.00
28	2.88	2.85	2.70	2.75	2.70	.....	3.00
29	2.88	3.13	2.68	2.70	2.70	.....	3.00
30	2.80	2.80	2.95	2.70	2.68	.....	3.00
31	.....	2.70	2.90	.....	2.75	.....	.....

TH BRANCH OF SHENANDOAH RIVER AT FRONT ROYAL, VIRGINIA.

'his stream rises in Augusta County, Virginia, and flows in a northterly direction, joining the North Branch of the Shenandoah at 'erton to form Shenandoah River. A station was established on South Branch by A. P. Davis, June 26, 1899. The measureıts of flow are made from an iron wire cable 300 feet in span, ıtched across the stream 3 miles southwest of Front Royal, Viria. The gage is a vertical timber divided into feet and tenths and ted to the trunk of a tree on the left bank of the stream. The ial point for sounding is on the left bank. The channel is straight feet above and below the station, and the current sluggish. The bank is low and liable to overflow. The bed of the stream is ky in part, with patches of sand somewhat shifting. The observer Miss Brentie Johnson, Front Royal, Virginia. One measurement ischarge was made by E. G. Paul, September 1, 1899; gage height,) feet; discharge, 616 second-feet.

Daily gage height, in feet, of South Branch of Shenandoah River at Front Royal, Virginia, for 1899.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	4.30	4.40	4.40	4.45	5.50	4.40
2	.....	4.30	4.35	4.35	4.40	8.05	4.40
3	.....	4.20	4.20	4.30	4.30	6.70	4.30
4	.....	4.20	4.25	4.20	4.30	5.85	4.30
5	.....	4.10	4.25	4.50	4.30	5.80	4.20
6	.....	4.20	4.20	4.30	4.30	5.65	4.20
7	.....	4.20	4.30	4.20	4.30	5.35	4.20
8	.....	4.25	4.65	4.15	4.35	5.20	4.20
9	.....	4.55	4.30	4.25	4.40	5.05	4.30
10	.....	4.70	4.50	4.75	4.40	4.85	4.30
11	.....	4.30	4.45	4.65	4.40	4.80	4.30
12	.....	4.20	4.30	4.55	4.40	4.70	4.45
13	.....	4.15	4.20	4.45	4.30	4.70	6.95
14	.....	4.20	4.20	4.40	4.30	4.60	6.25
15	.....	4.15	4.20	4.30	4.30	4.60	5.75
16	.....	4.25	4.30	4.30	4.20	4.55	5.45
17	.....	4.15	4.35	4.30	4.20	4.50	5.25
18	.....	4.15	4.25	4.20	4.20	4.50	5.15
19	.....	4.15	4.30	4.20	4.20	4.50	5.00
20	.....	4.10	4.25	4.55	4.20	4.50	4.95
21	.....	4.10	4.20	5.80	4.10	4.50	4.85
22	.....	4.10	4.10	5.30	4.15	4.40	4.75
23	.....	4.15	4.10	4.85	4.20	4.40	4.70
24	.....	4.10	4.00	4.60	4.20	4.50	4.90
25	.....	4.10	3.90	5.00	4.20	4.50	4.90
26	4.40	4.05	4.00	4.60	4.20	4.55	5.10
27	4.30	4.10	4.00	4.55	4.20	4.50	5.10
28	4.25	4.20	4.30	4.60	4.20	4.40	5.00
29	4.35	4.30	5.15	4.50	4.20	4.40	5.00
30	4.30	4.80	5.05	4.50	4.20	4.40	5.15
31	.....	4.25	4.60	.....	4.20	.....	.....

SHENANDOAH RIVER AT MILLVILLE, WEST VIRGINIA.

This river, formed by the junction of the North Fork and the South Fork at Riverton, Virginia, flows in a northeasterly direction into West Virginia, where it empties into the Potomac at Harpers Ferry.

Observations of the height of Potomac River at the junction of Shenandoah River have been made by the Weather Bureau at Harpers Ferry, West Virginia. The gage is on the west face and north end of the second abutment of the old railroad bridge from the West Virginia side of the river. It is of Portland cement, 15 inches wide, plastered on the face of the pier extending to 32 feet, and continued on the iron upright of the bridge to 36 feet. The top surface of the 6-by-6-inch-square capstone corresponds to the 32-foot mark on the gage. The elevation is 235.5 feet above mean sea level.

A station was established at Millville, West Virginia, April 15, 1895, on Shenandoah River, 4 miles above its mouth. A vertical gage was placed in the river and fastened to a tree, a deep notch being cut in the tree opposite the 8-foot mark. This gage is referred to a bench mark consisting of a copper bolt driven in the foot of a large sycamore tree on the left bank of the river 150 feet below the gage rod, at an elevation of 6.78 feet above the zero mark on the gage. Measurements are made from a cable stretched across the river. The old cable was carried away by the flood of 1896, and a new three-fourths

ı galvanized iron wire cable was put in place on June 23, 1897. ı cable, about 500 feet in length, is supported on either bank by a ;e sycamore tree, and is securely anchored on both sides. The nnel is straight, current swift and unobstructed. The banks are and subject to overflow. The observer is W. R. Nicewarner. · results of measurements may be found as follows: 1896, Eight-th Annual Report, Part IV, page 28; 1897, Nineteenth Annual ɔort, Part IV, page 151; 1898, Twentieth Annual Report, Part IV, e 127. The following measurements were made by E. G. Paul ing 1899:

nuary 27, gage height, 2.40 feet; discharge, 3,156 second-feet.
ırch 10, gage height, 5.00 feet; discharge, 10,838 second-feet.
ay 16, gage height, 2.10 feet; discharge, 2,753 second-feet.
ptember 3, gage height, 0.90 foot; discharge, 1,086 second-feet.
:tober 29, gage height, 0.60 foot; discharge, 766 second-feet.

y gage, height in feet, of Shenandoah River at Millville, West Virginia, for 1899.

›ay.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	2.30	Ice.	3.10	1.70	2.05	0.90	1.00	1.10	0.80	1.55	0.80
2	2.20	2.10	Ice.	3.00	1.60	2.35	.90	.80	.90	.70	2.75	.80
3	2.80	1.70	Ice.	2.80	1.60	3.00	.80	.90	.90	.70	3.20	.75
4	2.60	2.00	Ice.	2.70	1.60	2.10	.80	1.30	1.10	.70	2.40	.70
5	3.30	2.40	Ice.	2.60	2.00	1.80	.80	.90	.80	.70	1.90	.75
6	3.80	2.50	Ice.	2.50	1.90	1.50	.80	.80	.70	.70	1.80	.70
7	4.60	2.30	Ice.	2.40	1.90	1.40	.70	1.10	.80	.70	1.60	.70
8	6.70	2.50	Ice.	2.50	1.80	1.40	.80	1.00	.70	.70	1.40	.70
9	5.00	2.50	Ice.	3.10	2.00	1.50	.90	1.20	.70	.80	1.30	.70
0	4.50	2.30	5.00	3.00	2.30	1.40	1.00	1.00	.70	.80	1.20	.70
1	3.80	2.40	5.50	2.90	3.10	1.30	.90	1.60	.80	.70	1.10	.70
2	3.50	(a)	5.20	2.70	2.80	1.40	.80	.90	1.20	.80	1.00	.75
3	3.30	(a)	4.60	2.60	2.60	1.40	.80	.80	.90	.70	1.00	.90
4	3.00	2.30	4.00	2.50	2.70	1.30	.70	.90	.80	.70	1.00	2.90
5	2.90	2.40	4.00	2.40	2.20	1.30	.70	.80	.80	.70	.90	2.20
6	3.00	2.50	4.00	2.30	2.10	1.30	.90	.70	.70	.60	.90	1.90
7	2.90	2.70	4.50	2.20	1.90	1.20	.80	.80	.70	.60	.90	1.60
8	2.90	3.00	3.90	2.20	1.90	1.10	.70	.80	.60	.60	.80	1.40
9	2.90	3.00	3.80	2.20	2.50	1.00	.70	.80	.60	.60	.90	1.30
0	2.80	3.40	3.80	2.20	2.30	1.00	.70	.70	.80	.60	.80	1.20
1	2.60	4.00	3.80	2.20	2.00	1.00	.70	.70	.90	.60	.80	1.20
2	2.40	Ice.	3.70	1.90	1.90	.90	.70	.60	.90	.60	.80	1.10
3	2.40	Ice.	3.50	1.90	1.70	1.00	.60	.60	1.50	.60	.80	1.10
4	2.40	Ice.	3.30	1.90	1.70	.90	.60	.60	1.10	.60	.80	1.10
5	2.40	Ice.	3.10	1.80	1.60	.90	70	.50	1.00	.60	.80	1.30
6	2.30	Ice.	3.00	2.00	1.50	.90	.60	.50	.90	.50	.85	1.20
7	2.50	Ice.	2.90	1.90	1.50	.90	.60	.60	.90	.60	.85	1.70
8	2.30	Ice.	2.90	1.80	1.40	.90	.60	.70	.90	.60	.80	1 40
9	2.20	.....	3.00	1.80	1.40	.90	.60	.80	.80	.60	.80	1 05
0	2.10	.....	3.60	1.70	1.30	1.00	1.50	1.00	.80	.60	.80	1.10
1	2.10	.....	3.30	.....	1.60	.....	1.00	1.30	.....	.70	.....	1.10

a No readings.

POTOMAC RIVER AT POINT OF ROCKS, MARYLAND.

his station was established February 17, 1895, as described in letin 140, page 54. It is about 6 miles above the mouth of Monoc-River, and also above a number of smaller streams, and therefore measurements of discharge do not represent the entire flow of

Potomac River. The drainage area here is estimated to be 9,654 square miles. It is largely mapped on topographic atlas sheets—Harpers Ferry, Winchester, Romney, Piedmont, Warrensburg, Luray, Woodstock, Franklin, Beverly, Harrisonburg, Staunton, Monterey, Buckingham, and Lexington. Catoctin Creek enters the Potomac 1,000 feet above the station. The measurements are made from the highway bridge at Point of Rocks. The wire gage is on the east side of the first span, the scale being marked on the hand rail of the bridge. The gage is referred to two bench marks—one, a copper bolt in a large capstone on the lower wing wall of the north abutment, about 10 feet from the north end of the first iron truss, is 41.30 feet above the datum of the gage. The length of the wire gage is 44.22 feet. The gage was verified on October 29, 1899. The observer is G. H. Hickman. The records of flow may be found as follows: 1895–96, Eighteenth Annual Report, Part IV, page 32; 1897, Nineteenth Annual Report, Part IV, pages 152–153; 1898, Twentieth Annual Report, Part IV, page 131. The following measurements were made by E. G. Paul during 1899:

January 28, gage height, 3.80 feet; discharge, 17,330 second-feet.
May 20, gage height, 8.15 feet; discharge, 45,986 second-feet.
September 5, gage height, 0.80 foot; discharge, 2,360 second-feet.
October 29, gage height, 0.50 foot; discharge, 1,628 second-feet.

Mr. William Rich Hutton, of 35 Broadway, New York, states that in the summer of 1856 he made a careful examination of the flow of Potomac River a short distance below the Great Falls, using loaded poles reaching as near as possible to the bottom and placed at 5-foot intervals across the width of the river. The water was then at the lowest stage known to persons who had observed the river for many years. The discharge was 1,063 second-feet. Mr. Hutton was of the opinion that the river was as low in 1862, but no measurements were made in that year.

In 1839 a civil engineer, Mr. M. C. Ewing, assistant to Major Turnbull, United States topographic engineer, during the construction of the Alexandria Aqueduct above Georgetown, reported the discharge below Little Falls to be 1,904 second-feet. Mr. Thomas L. Patterson, of Cumberland, is reported to have found the discharge at that point in the low water of 1838 to be 24 second-feet, and at Patterson Creek, some 12 miles below, 48 second-feet. Figures of discharge of Potomac River are given in the statement regarding the extension of the Chesapeake and Ohio Canal in House Ex. Doc. No. 208, Forty-third Congress, first session; also in House Ex. Doc. No. 137, Forty-fourth Congress, first session.

Daily gage height, in feet, of Potomac River at Point of Rocks, Maryland, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.00	2.40	11.90	5.30	1.60	2.00	1.00	0.70	0.90	0.70	0.80	0.80
2	3.40	2.00	9.20	4.50	1.60	2.40	1.00	.70	.90	.60	1.50	.80
3	2.90	2.10	8.20	4.00	2.10	3.80	1.10	.70	.80	.60	2.50	.80
4	2.70	2.10	7.60	3.60	1.70	2.60	1.00	.90	.80	.60	2.00	.80
5	2.30	2.00	8.50	3.30	1.70	2.10	.90	1.00	.80	.60	1.80	.80
6	4.10	2.00	16.55	3.00	2.10	1.80	1.00	1.10	.70	.60	1.40	.70
7	6.90	2.00	12.90	2.80	2.00	1.60	2.00	1.10	.70	.70	1.40	.70
8	8.10	2.30	10.00	3.00	1.90	1.50	1.00	1.10	.60	.70	1.30	.70
9	6.80	2.30	8.10	3.50	2.00	1.40	1.00	1.00	.60	.70	1.20	.70
10	5.40	3.60	6.00	3.40	2.40	1.70	.90	1.00	.60	.60	1.00	.70
11	4.60	4.20	5.80	4.20	4.50	1.80	.90	.90	.60	.60	.90	.70
12	3.90	4.20	5.60	4.50	3.80	1.70	.80	.80	.80	.60	.90	.80
13	3.60	4.00	5.00	3.40	3.40	1.70	.80	.60	1.20	.60	.80	.80
14	3.40	3.90	4.80	3.20	3.20	1.60	.80	.60	1.10	.50	.80	1.20
15	3.40	3.80	4.50	3.00	2.80	1.50	.90	.60	1.00	.50	.80	3.00
16	4.00	4.00	4.60	2.80	2.50	1.50	1.10	.70	.90	.50	.80	2.10
17	5.70	4.50	4.70	2.70	2.30	1.40	.90	.70	.80	.50	.80	1.70
18	5.20	5.00	4.40	2.60	2.40	1.40	.70	.60	.70	.50	.70	1.50
19	4.70	5.20	5.20	2.50	8.55	1.30	.70	.60	.70	.50	.70	1.60
20	4.40	5.40	5.40	2.40	6.30	1.30	.70	.60	.90	.50	.70	1.50
21	4.00	6.00	5.30	2.20	5.00	1.20	.70	.60	.70	.50	.70	1.30
22	3.50	8.50	4.70	2.10	3.60	1.20	.70	.50	.80	.50	.70	1.10
23	3.30	14.80	4.20	2.00	3.00	1.10	.70	.50	.90	.50	.80	1.00
24	3.20	13.70	4.00	2.00	2.70	1.10	.60	.50	.90	.50	.80	1.20
25	3.30	9.00	3.90	2.00	2.40	1.00	.60	.50	.90	.50	.90	1.80
26	4.80	6.00	3.70	1.90	2.10	1.00	.60	.50	1.00	.50	.90	2.10
27	4.70	9.25	3.50	1.90	2.00	1.00	.60	1.20	.80	.50	.80	1.60
28	3.90	13.90	3.40	1.80	1.80	1.20	.60	1.10	.70	.50	.80	1.50
29	3.20	.....	3.60	1.70	1.70	1.10	.50	1.10	.70	.50	.80	1.60
30	2.80	.....	8.60	1.70	1.70	1.00	.80	1.00	.80	.50	.80	1.60
31	2.60	.....	7.00	.....	1.80	.....	.80	1.00	.....	.60	.....	1.60

MONOCACY RIVER AT FREDERICK, MARYLAND.

Monocacy River rises in the south-central part of Pennsylvania and flows in a southerly direction through Frederick County, Maryland, entering Potomac River near the Montgomery County line. A station was established by E. G. Paul, August 4, 1896, at the county iron bridge on the turnpike, 4 miles northeast of Frederick, on the road leading from Frederick to Mount Pleasant, Maryland, and about 2,000 feet above the mouth of Israel Creek and 3,000 feet below the mouth of Tuscarora Creek, as shown on the Frederick atlas sheet. The drainage area is 665 square miles at this point and 1,000 square miles at the mouth. The gage is attached to the floor timber on the lower side of the bridge. The length of the wire is 35.20 feet. The bench mark is a cross cut in the top face of the capstone on the lower retaining wall of the bridge abutment on the right bank of the stream, and is 29.17 feet above gage datum. The stream at this station has two channels, being divided by a small, low island, which serves as a foundation for the middle pier of the bridge. The right channel is measured from the lower side of the bridge, and the left channel from the upper side, as these sections are freer from rocks than a continuous section on either side of the bridge. The stream is subject to high water and sudden floods, owing to the character of its upper watershed. The observer is E. L. Derr, a farmer near Frederick, Maryland. Records of measurement can be found as follows:

1896, Eighteenth Annual Report, Part IV, page 35; 1897, Nineteenth Annual Report, Part IV, pages 153-155; 1898, Twentieth Annual Report, Part IV, page 129. Two measurements were made by E. G. Paul during 1899. The first, May 22, at a gage height of 5.20 feet, when the dischage was 633 second-feet. The second one was on September 6, at a gage height of 4.00 feet, with a discharge of 153 second-feet.

Daily gage height in feet of Monocacy River at Frederick, Maryland, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.40	5.20	11.50	7.10	4.80	7.10	4.10	3.90	4.30	4.00	7.30	4.10
2	5.00	5.20	10.10	6.90	4.60	11.10	4.10	4.00	4.30	3.90	6.40	4.10
3	5.50	5.80	9.20	6.50	5.00	7.05	4.10	5.10	5.40	3.90	6.30	4.10
4	6.00	5.60	8.70	6.10	4.90	5.20	4.00	5.00	5.00	3.90	6.00	4.10
5	6.30	5.90	17.15	6.00	4.90	4.80	4.00	5.00	4.50	3.80	5.30	4.10
6	12.75	5.70	11.45	6.00	4.80	4.70	4.50	4.90	4.00	3.80	5.00	4.00
7	14.85	5.50	8.90	7.60	4.80	4.50	4.40	4.50	3.90	3.90	4.50	4.00
8	12.50	5.40	7.80	12.60	5.20	4.50	4.20	4.00	3.80	3.90	4.40	3.90
9	10.20	6.00	7.50	8.50	6.60	5.50	4.30	4.00	3.70	4.10	4.30	3.90
10	6.10	6.00	7.40	6.90	5.60	6.85	4.20	4.00	4.00	4.10	4.30	3.90
11	6.10	6.00	7.40	6.50	5.40	6.90	4.20	4.00	4.00	4.00	4.20	3.90
12	5.70	6.00	7.30	6.20	5.80	6.50	4.10	4.20	3.90	4.00	4.10	4.80
13	5.80	6.00	7.10	5.90	5.40	5.20	4.30	4.00	3.90	3.90	4.10	5.95
14	6.00	6.00	6.50	5.60	5.00	4.90	4.20	3.90	3.80	3.90	4.10	5.50
15	6.80	6.00	6.50	5.60	5.00	6.20	4.20	3.90	3.80	3.90	4.10	4.50
16	6.60	6.00	9.70	5.60	4.90	5.10	4.50	3.90	3.80	3.90	4.10	4.40
17	6.60	6.20	6.90	5.60	5.20	4.80	4.30	3.90	3.70	3.90	4.10	4.40
18	7.10	6.80	7.90	5.60	6.50	4.50	4.30	3.80	3.70	4.00	4.10	4.30
19	6.40	7.90	13.90	5.60	7.70	4.40	4.20	3.80	3.70	3.90	4.10	4.20
20	5.60	9.00	10.10	5.40	6.90	4.40	4.10	3.80	6.00	3.90	4.10	4.20
21	5.60	12.50	7.90	5.20	6.50	4.40	4.00	3.80	5.30	3.80	4.10	4.50
22	5.60	13.50	7.80	5.10	5.20	4.30	3.90	3.80	5.00	3.80	4.10	4.40
23	5.60	15.65	7.60	5.10	5.20	4.30	3.90	3.80	4.90	3.80	4.10	4.30
24	5.70	11.60	7.20	5.00	5.00	4.30	3.90	3.80	4.50	3.80	5.30	7.10
25	10.40	9.10	6.70	5.00	4.90	4.20	4.30	3.80	4.30	3.80	4.70	6.90
26	8.20	9.10	6.70	5.00	4.80	4.20	4.50	3.80	5.25	3.80	4.40	6.20
27	6.50	17.80	6.70	5.00	4.70	4.20	4.40	4.70	5.50	3.80	4.30	6.00
28	5.20	12.50	10.15	4.90	4.70	4.20	4.30	4.95	5.30	3.80	4.30	5.10
29	5.20	.....	11.00	4.90	4.60	4.20	4.20	4.70	5.00	3.80	4.20	5.10
30	5.20	.....	8.10	4.80	5.00	4.20	4.00	4.30	4.50	3.80	4.20	5.10
31	5.20	.....	7.90	.....	5.00	.....	3.90	4.30	.....	5.00	.....	.....

ROCK CREEK AT ZOOLOGICAL PARK, DISTRICT OF COLUMBIA.

This creek rises in Montgomery County, Maryland, and flows in a southerly direction through the District of Columbia, emptying into Potomac River. A study of the discharge of Rock Creek was begun in 1892, at the request of the Commissioners of the District of Columbia, and a gage rod established by Cyrus C. Babb at Lyons Mill. In August, 1892, a self-registering gage was placed at the bridge, and the record continued until November 30, 1894. The present station was established January 18, 1897, by E. G. Paul, at the bridge of the National Zoological Park, District of Columbia. The upper part of the gage is vertical and is fastened to the bridge abutment, the lower part being inclined and fastened to the iron rods. The bench mark consists of a cross cut in the stone of the bridge pier. It is 9.13 feet above the zero of the gage. The observer is W. V. Kramer, a park watchman.

Daily gage height in feet of Rock Creek at Zoological Park, District of Columbia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.05	2.78	3.30	3.00	2.75	2.88	2.40	2.35	2.40	2.58	3.65	2.53
2	2.75	2.88	3.23	2.93	2.70	2.68	2.40	2.35	2.40	2.50	2.83	2.58
3	2.88	2.88	3.13	2.90	2.73	2.63	2.35	3.90	2.40	2.50	2.80	2.53
4	2.90	2.95	3.10	2.90	2.70	2.60	2.35	3.20	2.40	2.50	3.10	2.50
5	3.33	3.13	4.50	2.90	2.70	2.55	2.60	2.65	2.38	2.50	2.80	2.50
6	3.60	3.00	3.40	2.90	2.70	2.55	2.58	2.90	2.30	2.75	2.70	2.50
7	4.25	3.00	3.18	2.95	2.75	2.55	2.70	2.55	2.30	2.70	2.63	2.50
8	3.23	2.93	3.10	3.80	2.75	2.55	2.50	2.50	2.30	2.58	2.60	2.50
9	3.05	2.63	3.10	3.08	3.23	2.50	2.78	2.48	2.30	2.60	2.60	2.50
10	3.00	2.93	3.08	3.00	2.83	3.63	2.48	2.53	2.30	2.58	2.60	2.50
11	3.00	2.78	3.23	2.90	2.83	2.98	2.43	2.50	2.40	2.55	2.60	2.50
12	3.10	2.78	3.18	2.90	2.98	2.73	2.40	2.48	2.43	2.50	2.58	2.78
13	2.90	2.78	3.13	2.90	2.78	2.65	2.50	2.45	2.30	2.50	2.55	2.75
14	3.00	2.78	3.00	2.90	2.73	2.63	2.70	2.75	2.30	2.50	2.55	2.63
15	3.00	2.95	3.10	2.85	2.70	2.55	2.45	2.50	2.30	2.50	2.55	2.53
16	3.00	2.95	3.30	3.05	2.68	2.50	2.45	2.70	2.25	2.50	2.55	2.50
17	3.10	4.00	3.00	3.00	2.73	2.50	2.90	2.50	2.25	2.50	2.55	2.50
18	3.08	4.25	3.05	2.90	3.25	2.50	2.58	2.45	2.30	2.50	2.55	2.55
19	2.98	4.43	3.90	2.85	2.95	2.50	2.45	2.43	2.43	2.50	2.58	2.60
20	2.93	4.05	3.33	2.85	2.78	2.50	2.40	2.40	3.00	2.50	2.55	2.60
21	3.13	3.88	3.10	2.80	2.70	2.48	2.40	2.40	2.63	2.50	2.55	2.60
22	2.85	4.18	3.18	2.80	2.70	2.45	2.40	2.73	2.55	2.45	2.55	2.55
23	2.85	4.10	3.18	2.80	2.68	2.45	2.40	2.45	2.40	2.45	2.60	2.50
24	2.85	3.50	3.03	2.80	2.65	2.45	2.40	2.35	2.35	2.48	2.63	2.93
25	3.68	3.20	3.00	2.80	2.60	2.48	2.40	2.30	2.65	2.45	2.60	2.95
26	3.08	3.15	3.00	2.80	2.60	2.53	2.50	2.30	5.25	2.45	2.60	2.68
27	3.00	3.70	3.00	2.83	2.60	2.50	2.50	2.55	3.75	2.50	2.55	2.53
28	2.88	3.33	3.23	2.78	2.60	2.48	2.40	2.75	2.85	2.50	2.55	2.60
29	2.85	.....	3.45	2.75	2.65	2.45	2.40	2.48	2.60	2.50	2.55	2.53
30	2.83	.....	3.15	2.75	2.60	2.43	2.40	2.40	2.60	2.50	2.55	2.53
31	2.85	.....	3.03	.....	2.60	.....	2.38	2.40	.....	2.63	.....	2.50

NORTH ANNA RIVER, VIRGINIA.

Measurements of North Anna River, a tributary of Pamunkey River, were made in August, 1896, by J. O. Smith and A. Langstaff Johnston, of Richmond, Virginia, at Mr. Smith's mill, at a point about 1 mile above the Hanover County line; also at McGeehees Bridge, about 3 miles above the mill. At that time the river was at its lowest stage for the year. During the winter the volume is believed to be four or five times greater. The measurements at the mill gave an average area of 148 square feet and an average velocity of 0.69 foot per second, the total discharge being 102 second-feet. The measurements at McGeehees Bridge showed an average area of 184 square feet and an average velocity of 0.50 foot per second, giving a discharge of 92 second-feet.

NORTH RIVER AT GLASGOW, VIRGINIA.

This river rises on the western slope of the Shenandoah Mountains, and flows in a southeasterly direction across the valley between the Shenandoah and Blue Ridge ranges, emptying into James River about 17 miles south of Lexington, Virginia. Its watershed is largely under cultivation, except in the upper part, where it is mountainous and covered with forest growth. The entire drainage area is mapped on the Lexington, Monterey, Staunton, and Natural Bridge atlas sheets. This station was established at the East Glasgow County Bridge,

about 1 mile above the mouth of North River, by C. C. Babb and D. C. Humphreys, on August 21, 1895. The height of water is observed by means of a wire gage, the board being placed on the guard rail on the lower side of the bridge, and graduated in feet and tenths. This gage is referred to a bench mark at the top of the top chord of the bridge over the gage pulley at an elevation of 32.24 feet. The distance from the end of the weight to the marker of the gage is 27.86 feet. The measurements of discharge are made from the bridge, the initial point for soundings being on the left bank. The channel is straight for about 200 feet above and below the station; the current rather sluggish, but with sufficient velocity for measurements. There is a dam on the North River 10 miles above the station, but its influence on the flow is scarcely noticeable. The right bank is high, but the left bank is subject to overflow in very high water. The bed is of rock and gravel, and fairly permanent. The observer is B. G. Baldwin, a merchant of Glasgow, Virginia. Results of measurements may be found as follows: 1895–96, Eighteenth Annual Report, Part IV, page 38; 1897, Nineteenth Annual Report, Part IV, page 162; 1898, Twentieth Annual Report, Part IV, page 135. The following discharge measurements were made during 1899 by D. C. Humphreys:

March 30, gage height, 2.82 feet; discharge, 2,039 second-feet.
June 27, gage height, 0.95 foot; discharge, 227 second-feet.
August 7, gage height, 0.92 foot, discharge 218 second-feet.

At this last measurement the velocity was barely sufficient to turn the meter and surface floats indicated that the discharge should be somewhat greater.

Daily gage height, in feet, of North River at Glasgow, Virginia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.05	1.80	(a)	2.60	1.42	1.38	0.90	0.72	0.85	0.95	2.50	0.73
2	2.10	1.72	(a)	2.43	1.42	1.48	.80	.72	.82	.90	1.50	.75
3	2.00	1.80	(a)	2.35	1.43	1.40	.82	.73	.82	.85	1.35	.78
4	2.30	2.30	(a)	2.20	1.42	1.30	.80	.75	.82	.85	1.25	.76
5	2.52	b 2.80	13.05	2.15	1.42	1.25	.80	.75	.80	.85	1.20	.76
6	4.01	3.30	(a)	2.10	1.48	1.21	.78	.75	.71	.85	1.10	.78
7	7.00	3.15	(a)	2.10	1.52	1.15	.80	.90	.71	.84	1.05	.75
8	b 5.38	2.80	(a)	2.80	1.62	1.12	.80	.80	.70	.87	1.00	.78
9	3.75	2.30	(a)	2.55	3.75	1.10	.80	.73	1.10	.98	.95	.78
10	3.30	2.30	(a)	2.42	2.85	1.10	.95	.73	1.00	.90	.93	.75
11	2.95	2.28	(a)	2.35	2.45	1.08	.88	.72	.90	.85	.92	.73
12	2.60	b 2.27	(a)	2.30	1.85	1.30	.80	.72	1.00	.82	.92	1.25
13	2.45	2.26	(a)	2.22	2.30	1.40	.80	.73	.95	.80	.92	2.10
14	2.45	2.25	(a)	2.12	2.25	1.30	.80	.77	.90	.75	.84	1.85
15	2.38	2.25	(a)	2.10	2.15	1.20	.80	1.92	.80	.70	.80	1.50
16	2.35	2.26	(a)	2.00	2.00	1.20	.80	1.10	.75	.65	.80	1.42
17	2.28	2.30	(a)	1.94	1.90	1.18	.80	.88	.73	.68	.83	1.25
18	2.25	2.45	(a)	1.90	1.80	1.10	.80	.80	.72	.68	.80	1.12
19	2.20	2.75	(a)	1.82	1.80	1.02	.75	.72	.72	.70	.65	1.12
20	2.10	3.30	(a)	1.80	1.62	1.00	.72	.72	2.62	.70	.80	1.08
21	2.05	4.80	(a)	1.77	1.58	.95	.72	.72	1.32	.72	.79	1.05
22	2.02	6.85	(a)	1.72	1.55	.92	.72	.70	1.22	.70	.78	1.00
23	2.00	5.45	(a)	1.68	1.52	.90	.70	.70	1.15	.73	.78	1.10
24	1.90	5.35	(a)	1.65	1.46	.90	.70	.63	1.00	.73	.74	1.12
25	2.00	5.15	(a)	1.62	1.38	.95	.71	.62	1.00	.72	.74	1.20
26	2.05	.....	(a)	1.65	1.30	1.00	.72	.62	.98	.72	.72	1.30
27	2.00	6.15	(a)	1.62	1.28	.95	.75	b 1.00	1.10	.72	.70	1.10
28	2.00	.....	(a)	1.60	1.25	.95	.75	1.62	1.08	.72	.65	1.15
29	1.95	.....	(a)	1.53	1.22	1.00	.74	1.35	1.00	.71	.70	1.20
30	1.90	.....	2.90	1.48	1.48	.97	.72	1.02	.98	.70	.75	1.21
31	1.85	.....	2.72	.....	1.46	.....	.72	.92	.....	.85	.....	1.00

a No observations. b Interpolated.

JAMES RIVER AT BUCHANAN, VIRGINIA.

This river rises in the Allegheny Mountains, on the western border of Virginia, and flows in an easterly direction across the State into Chesapeake Bay. The upper part of its drainage area is mountainous and largely covered with forests, while in the eastern part of the State the river flows through a flat and cultivated area. Measurements of flow are made at Buchanan, in Botetourt County, and at Cartersville, 50 miles above Richmond. The station at Buchanan was established by C. C. Babb and D. C. Humphreys, August 18, 1895. It is about 20 miles above the mouth of North River and one-half mile above the mouth of Purgatory Creek, as shown on the Natural Bridge topographic atlas sheet. The area as far as this point is mapped on the Natural Bridge, Staunton, Monterey, Lewisburg, Dublin, Christiansburg, and Roanoke sheets. The United States Weather Bureau had maintained a gage here for about two years before measurements were made by the Geological Survey. The wire gage is suspended from the steel highway bridge which crosses the river on two spans. On April 3, 1897, the zero of this gage was lowered 2 feet to avoid negative readings. The gage is referred to a scale divided into feet and tenths, and to two bench marks. First, the top of the upper end of the third floor beam from left bank is 30.00 feet above the zero of the gage. Second, the top of a stone post under the southwest corner of the porch of the Chesapeake and Ohio Railroad passenger station is 24.68 feet above zero of gage. A third bench mark is on a permanent ledge of rock on the left bank about 500 feet above the bridge, and at an elevation of 17.48 feet above the zero of the gage. The initial point of soundings is on the left bank, upper side of the bridge, marked with the end pin of the truss. The channel is straight, the flow fairly swift, and without obstructions. The bed is rocky; banks high and not subject to overflow. The observer is U. H. Hyde, a telegraph operator for the Chesapeake and Ohio Railroad, at Buchanan, Virginia. The results of measurement may be found as follows: 1895–96, Eighteenth Annual Report, Part IV, page 41; 1897, Nineteenth Annual Report, Part IV, page 172; 1898, Twentieth Annual Report, Part IV, page 136. During 1899 three measurements of discharge were made by D. C. Humphreys; the first on March 30, at a gage height of 5.54 feet, gave a discharge 6,804 second-feet; the second on July 6, at a gage height of 2.06 feet, gave a discharge 558 second-feet, and the third on August 11, at a gage height of 1.80 feet, gave a discharge of 364 second-feet.

Daily gage height, in feet, of James River at Buchanan, Virginia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.45	3.10	7.45	4.75	3.80	3.60	3.00	1.90	1.90	1.90	1.80	1.80
2	3.55	3.00	6.55	4.40	3.80	3.70	2.10	1.90	1.90	1.90	1.90	1.80
3	3.40	3.00	6.40	4.30	3.80	3.60	2.10	1.80	1.90	1.90	2.10	1.80
4	3.40	3.40	11.20	4.20	3.80	3.60	2.00	1.80	2.00	1.90	2.30	1.80
5	3.95	4.90	19.05	4.10	3.70	3.60	2.00	1.80	2.10	1.90	2.20	1.80
6	5.95	6.80	13.55	4.10	3.70	3.50	2.05	1.80	2.00	1.80	2.20	1.80
7	10.25	8.40	8.15	4.00	4.05	3.40	2.12	1.80	1.90	1.80	2.10	1.80
8	7.70	7.30	6.70	5.00	5.35	3.30	2.35	1.90	1.80	1.80	2.10	1.80
9	5.95	6.30	5.90	5.75	7.70	3.30	2.35	1.90	2.00	1.80	2.10	1.80
10	5.20	4.50	5.55	5.40	6.05	3.30	2.15	1.90	2.10	1.80	2.00	1.80
11	4.60	4.05	5.35	5.00	5.85	3.30	2.00	1.90	2.20	1.80	2.00	1.80
12	4.20	4.00	5.15	4.85	5.65	3.30	2.00	1.90	2.10	1.80	1.90	2.30
13	4.00	4.00	4.95	4.70	5.60	4.45	2.00	1.90	2.10	1.80	1.90	3.50
14	3.85	3.95	4.65	4.60	6.20	4.50	2.00	2.00	2.00	1.80	1.90	3.05
15	4.15	3.50	4.75	4.45	5.70	4.25	1.90	2.60	2.00	1.80	1.90	2.95
16	4.30	3.60	5.55	4.45	5.20	3.95	1.90	2.45	1.90	1.80	1.90	2.60
17	4.20	3.75	5.30	4.30	4.85	3.70	1.90	2.20	1.90	1.80	1.80	2.45
18	4.20	4.15	5.05	4.05	4.65	3.55	1.90	2.00	1.80	1.80	1.80	2.30
19	4.05	4.85	7.15	4.00	4.50	3.40	1.90	1.90	2.45	1.80	1.80	2.20
20	3.75	5.70	7.80	3.90	4.35	3.30	1.90	1.90	3.60	1.80	1.80	2.20
21	3.60	8.20	6.35	3.90	4.05	3.20	1.90	1.80	3.40	1.70	1.80	2.10
22	3.50	10.20	5.65	3.80	4.00	3.10	1.80	1.80	2.65	1.70	1.80	2.10
23	3.50	9.35	5.20	3.80	3.90	3.10	1.80	1.80	2.35	1.70	1.80	2.10
24	3.40	7.35	4.80	3.70	3.90	3.00	1.80	1.80	2.20	1.70	1.80	2.10
25	3.40	6.15	4.55	3.70	3.90	3.15	1.80	1.80	2.10	1.70	1.80	2.10
26	3.60	5.40	4.25	3.85	3.80	3.10	1.80	1.80	2.10	1.70	1.80	2.25
27	3.50	8.90	4.10	4.20	3.60	3.65	1.90	1.90	2.00	1.70	1.80	2.30
28	3.40	9.65	4.00	4.00	3.60	3.30	1.90	1.80	2.00	1.70	1.80	2.20
29	3.30	.....	4.80	4.00	3.50	3.20	2.00	2.00	2.00	1.70	1.80	2.20
30	3.20	.....	5.55	3.90	3.60	3.10	2.00	1.90	1.90	1.70	1.80	2.20
31	3.10	.....	5.75	.....	3.60	.....	1.90	1.90	.....	1.70	.....	2.20

JAMES RIVER AT CARTERSVILLE, VIRGINIA.

Observations of the height of James River are made by the Weather Bureau at Lynchburg, Virginia, 48 miles below Buchanan and about 100 miles above Cartersville. The drainage area is given as 3,700 square miles. The gage is on the first pier of the Amherst bridge, at the foot of Ninth street, on the side facing Lynchburg, about 100 feet from the shore. The elevation is 494.7 feet above mean sea level. The highest water was about 27 feet on September 30, 1870, and the lowest —0.3 foot on September 12–15, 1895.

Gages were established on James River in 1893 by Mr. F. B. Isaacs, engineer for water power of the Chesapeake and Ohio Railway Company, at Ninemile Locks, Columbia, Scottsville, Lynchburg, Balcony Falls, Buchanan, Eagle Mountain, and Clifton Forge. Records of heights of water at these points were made twice daily from 1893 to 1897, and freshet reports were obtained for these years. The gages were not referred to any fixed datum, but the zero of each gage was set at what was considered ordinary low water in the river. During the latter part of 1899 records have been resumed, excepting at Scottsville, Balcony Falls, and Eagle Mountain, where the gages have been abandoned.

At Bosher's dam, 9 miles above Richmond, is a gage where the height of water is recorded twice daily, showing the supposed head on the crest of dam. This crest, however, is so irregular that the coefficient of discharge has not been ascertained. Another complication exists in the fact that water is deflected into a canal, the quantity not being known.

Observations are maintained by the Weather Bureau at Richmond, Virginia, the gage being at the foot of Virginia street, near Fourteenth, immediately east of the Richmond and Danville Railroad bridge. It is a standard brass Weather Bureau gage embedded in the cement buttress. The elevation of the zero is 2.8 feet.

A gaging station was established January 1, 1899, by Prof. D. C. Humphreys, and is located at the highway bridge crossing the James at Cartersville, one-half mile from railroad station and 50 miles above Richmond, Virginia. The drainage area is mapped on the following atlas sheets: Goochland, Farmville, Palmyra, Gordonsville, Harrisonburg, Buckingham, Lexington, Lynchburg, Appomatox, Natural Bridge, Lewisburg, Christiansburg, Roanoke, Staunton, Monterey, and Dublin. The wire gage is attached to a horizontal gage rod fastened to the bridge and is referred to a bench mark, the top of the lower end of the fourth floor beam from the right bank, which is 32.04 feet above the zero of the gage. The gage was verified June 23, 1899. The channel is straight for one-third of a mile above and 1 mile below the station, the current fairly swift, and the bottom somewhat sandy and shifting. The banks are high and not subject to overflow except in extreme high water. The observer is Julien I. Palmore, clerk in a store at Cartersville, Virginia. The following measurements were made by Prof. D. C. Humphreys and F. H. Anschutz. Prior to 1899 two measurements were made, which have not previously been published:

September 8, 1897, gage height, 0.42 foot; discharge, 603 second-feet.
July 16, 1898, gage height, 1.04 feet; discharge, 1,323 second-feet.
January 3, 1899, gage height, 3.82 feet; discharge, 7,156 second-feet.
June 23, 1899, gage height, 1.46 feet; discharge, 2,686 second-feet.

Daily gage height, in feet, of James River at Cartersville, Virginia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.40	3.30	13.90	6.05	3.00	2.30	1.53	1.30	1.40	1.30	4.97	1.20
2	4.40	3.25	10.35	5.62	2.85	2.20	1.35	1.10	1.32	1.15	4.15	1.20
3	3.70	3.20	8.80	5.15	2.80	2.70	1.25	1.00	2.90	1.10	3.60	1.20
4	4.00	4.30	9.40	4.65	3.05	2.40	1.12	.90	1.44	1.10	5.30	1.20
5	4.00	5.65	20.25	4.60	2.80	2.27	1.22	.85	1.35	1.10	3.30	1.20
6	8.20	7.50	24.70	4.25	2.80	2.10	1.25	2.30	1.15	1.05	2.80	1.20
7	19.50	8.80	19.25	4.15	3.65	2.05	1.30	2.00	1.15	1.00	2.50	1.20
8	15.40	10.50	13.17	9.55	4.50	1.97	1.47	1.45	1.30	1.80	2.20	1.15
9	11.74	8.75	10.40	8.50	5.00	1.75	1.20	1.35	1.60	2.00	1.95	1.10
10	9.00	6.40	10.90	8.15	6.20	1.80	1.15	1.10	1.44	2.05	1.85	1.00
11	7.05	5.10	8.60	7.12	6.50	2.00	1.06	1.00	1.27	1.50	1.60	1.00
12	5.98	5.10	7.30	6.15	7.30	2.30	1.24	1.26	1.20	1.40	1.50	1.10
13	5.40	5.10	7.10	4.90	5.05	3.10	1.09	1.19	1.30	1.30	1.45	3.15
14	5.17	5.10	6.90	4.70	5.65	3.45	1.02	1.09	1.31	1.20	1.75	2.80
15	5.17	6.00	8.12	4.50	5.15	3.40	1.00	1.10	1.13	1.10	1.50	3.10
16	4.70	7.75	10.65	4.15	5.15	3.47	1.07	2.04	1.05	1.10	1.30	2.90
17	5.47	14.00	8.30	4.07	4.45	3.00	1.00	2.12	1.00	1.00	1.30	2.80
18	5.15	9.75	8.05	3.95	3.90	2.10	1.04	1.40	.92	1.20	1.25	2.40
19	4.73	10.55	17.33	3.75	3.65	2.00	1.15	1.30	.85	1.10	1.25	1.80
20	4.50	10.55	18.32	3.60	3.40	1.78	1.05	1.15	3.40	1.00	1.25	1.80
21	4.20	14.00	12.83	3.55	3.17	1.70	.88	.97	5.40	.98	1.25	1.60
22	4.05	16.10	8.80	3.47	2.86	1.50	.82	.80	3.40	.97	1.25	1.50
23	3.85	16.30	8.00	3.32	2.80	1.48	.80	.80	2.65	.98	1.25	1.45
24	3.75	13.75	7.60	3.17	2.70	1.40	.77	.82	2.10	1.00	1.25	1.60
25	4.30	11.00	6.65	3.08	2.50	1.40	.70	.76	1.30	1.00	1.25	1.80
26	4.10	8.65	6.15	3.05	2.45	1.70	.80	.66	3.50	.98	1.25	2.00
27	3.80	10.90	5.85	3.20	2.45	2.10	2.23	7.00	2.35	.97	1.20	2.10
28	3.75	12.30	5.25	3.25	2.15	1.60	2.30	6.45	1.70	.97	1.20	2.00
29	3.55	.....	6.35	3.30	2.05	1.40	1.33	3.50	1.40	.97	1.20	1.80
30	3.50	.....	6.15	3.10	2.20	1.80	1.40	2.70	1.30	.97	1.20	1.75
31	3.42	.....	6.55	.....	2.25	.....	1.70	1.84	.....	.97	.....	1.65

NOTE.—Data concerning other rivers are given in succeeding papers of this series, beginning on page 107 of Water-Supply Paper No 36. By the law approved June 11, 1896 (Stat. L., vol. 29, p. 453), the reports of this series are limited to 100 pages each. It is therefore necessary to arbitrarily subdivide this report on operations at river stations.

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1895.

Sixteenth Annual Report of the United States Geological Survey, 1894-95, Part II, Papers of an economic character, 1895; octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnaissance of northwestern Wyoming, by George H. Eldridge 1894; octavo, 72 pp. Bulletin No. 110 of the United States Geological Survey, price, 10 cents.

Contains a description of the geologic structure of portions of the Bighorn Range and Bighorn Basin, especially with reference to the coal fields and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar years 1893 and 1894, by F. H. Newell, 1895; octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895-96, Part II, Economic geology and hydrography, 1896; octavo, 884 pp.

Contains papers on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett, and "Preliminary report on the artesian waters of a portion of the Dakotas," by N. H. Darton.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 336 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896-97, Part IV, Hydrography, 1897; octavo, 756 pp.

Contains a "Report of progress of stream measurements for the calendar year 1896," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "New developments in well boring and irrigation in South Dakota," by N. H. Darton, and "Reservoirs for irrigation," by J. D. Schuyler.

1899.

Nineteenth Annual Report of the United States Geological Survey, 1897-98, Part IV, Hydrography, 1899; octavo, 814 pp.

Contains a "Report of progress of stream measurements for the calendar year 1897," by F. H. Newell and others; "The rock waters of Ohio," by Edward Orton, and "A preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian," by N. H. Darton.

1900.

Twentieth Annual Report of the United States Geological Survey, 1898-99, Part IV, Hydrography, 1900; octavo, 660 pp.

Contains a "Report of progress of stream measurements for the calendar year 1898," by F. H. Newell, and "Hydrography of Nicaragua," by A. P. Davis.

Water-Supply and Irrigation Papers, 1896-1900.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost, as noted above. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Postage stamps, checks, and drafts can not be accepted. Correspondence relating to the publications of the Survey should be addressed to **The Director, United States Geological Survey, Washington, D. C.**

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phoenix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 18
7. Seepage waters of northern Utah, by Samuel Fortier, 1897.
8. Windmills for irrigation, by E. C. Murphy, 1897.
9. Irrigation near Greeley, Colorado, by David Boyd, 1897.
10. Irrigation in Mesilla Valley, New Mexico, by P. C. Barker, 1898.
11. River heights for 1896, by Arthur P. Davis, 1897.
12. Water resources of southeastern Nebraska, by Nelson Horatio Darton, 1
13. Irrigation systems in Texas, by William Ferguson Hutson, 1898.
14. New tests of pumps and water lifts used in irrigation, by O. P. Hood, 1
15. Operations at river stations, 1897, Part I, 1898.
16. Operations at river stations, 1897, Part II, 1898.
17. Irrigation near Bakersfield, California, by C. E. Grunsky, 1898.
18. Irrigation near Fresno, California, by C. E. Grunsky, 1898.
19. Irrigation near Merced, California, by C. E. Grunsky, 1899.
20. Experiments with windmills, by Thomas O. Perry, 1899.
21. Wells of northern Indiana, by Frank Leverett, 1899.
22. Sewage irrigation, Part II, by George W. Rafter, 1899.
23. Water-right problems of the Bighorn Mountains, by Elwood Mead, 1899
24. Water resources of the State of New York, Part I, by George W. Rafter, 1
25. Water resources of the State of New York, Part II, by George W. Rafter, 1
26. Wells of southern Indiana (continuation of No. 21), by Frank Leverett, 1
27. Operations at river stations, 1898, Part I, 1899.
28. Operations at river stations, 1898, Part II, 1899.
29. Wells and windmills in Nebraska, by Erwin Hinckley Barbour, 1899.
30. Water resources of the Lower Peninsula of Michigan, by Alfred C. Lane, 1
31. Lower Michigan mineral waters, by Alfred C. Lane, 1899.
32. Water resources of Puerto Rico, by H. M. Wilson, 1900.
33. Storage of water on Gila River, Arizona, by J. B. Lippincott, 1900.
34. Underground waters of a portion of southeastern S. Dak., by J. E. Todd, 1
35. Operations at river stations, 1899, Part I, 1900.
36. Operations at river stations, 1899, Part II, 1900.
37. Operations at river stations, 1899, Part III, 1900.

In addition to the above, there are in various stages of preparation other pa relating to the measurement of streams, the storage of water, the amount avail from underground sources, the efficiency of windmills, the cost of pumping, other details relating to the methods of utilizing the water resources of the c try. Provision has been made for printing these by the following clause in sundry civil act making appropriations for the year 1896–97:

Provided, That hereafter the reports of the Geological Survey in relation to gaging of streams and to the methods of utilizing the water resources ma printed in octavo form, not to exceed 100 pages in length and 5,000 copies in n ber; 1,000 copies of which shall be for the official use of the Geological Sur 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivere the House of Representatives, for distribution. [Approved June 11, 1896; Stat vol. 29, p. 453.]

The maximum number of copies available for the use of the Geological Su is 1,000. This number falls far short of the demand, so that it is impossibl supply all requests. Attempts are made to send these pamphlets to persons have rendered assistance in their preparation through replies to schedules or have furnished data. Requests specifying a certain paper and stating a reason asking for it are granted whenever practicable, but it is impossible to co with general and indiscriminate demands, such as to have all of the series se

Application for these papers should be made either to Members of Congress

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D.

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 36

OPERATIONS AT RIVER STATIONS, 1899.—PART II

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

IRRIGATION REPORTS.

The following list contains the titles and brief descriptions of the principal reports relating to water supply and irrigation prepared by the United States Geological Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 128 pp.

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo, 395 pp.

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889-90. Contains a description of the hydrography of the arid region and of the engineering operations carried on by the Irrigation Survey during 1890; also the statement of the Director of the Survey to the House Committee on Irrigation, and other papers, including a bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891; octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890-91. Contains "Report upon the location and survey of reservoir sites during the fiscal year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; and "Irrigation in India," by Herbert M. Wilson. Illustrated by 40 plates and 190 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell; quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No. 172, Irrigation in Oregon; No. 190, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 34, September 9, 1892; quarto, 23 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a résumé of the water supply and a description of irrigation by artesian wells. Illustrated by colored maps showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-92, Part III, Irrigation, 1893; octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American irrigation engineering" and "Engineering results of the Irrigation Survey," by Herbert M. Wilson; and "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, 1893; octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical conditions and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892-93, in two parts; Part II, Accompanying papers, 1894; octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W. J. McGee; "Natural mineral waters of the United States," by A. C. Peale; and "Results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 36

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

H. C. Branner

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

PERATIONS AT RIVER STATIONS, 1899

A REPORT OF THE

DIVISION OF HYDROGRAPHY

OF THE

UNITED STATES GEOLOGICAL SURVEY

PART II

WASHINGTON

GOVERNMENT PRINTING OFFICE

1900

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OPERATIONS AT RIVER STATIONS, 1899.

PART II.

MEASUREMENTS AT RIVER STATIONS.[1]

ROANOKE RIVER AT ROANOKE, VIRGINIA.

This river rises in Montgomery County, Virginia. Its headwaters are near those of New River on the west. This stream lower down is known as Staunton River, and joins the Dan at Danville to form the main lower Roanoke River. There are a number of fine water powers along its length, described more fully in the Nineteenth Annual Report, Part IV, page 176. The drainage area is mapped on the Roanoke and Christiansburg sheets. The gaging station was established by Prof. D. C. Humphreys July 10, 1896, and is located on the edge of the town of Roanoke, Virginia, on the Walnut street car line. The gage is of wire, with the rod fastened to the floor of the bridge. The top of the lower end of the first floor beam is 21:99 feet above gage datum. The length of gage wire is 24.39 feet. The right bank is above high water, but the left is liable to overflow in extreme high stages. The channel is nearly straight and the current good. The results of discharge measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 42; 1897–98, Twentieth Annual Report, Part IV, page 140. The following measurements were made during 1899 by D. C. Humphreys: The first, on May 29, at a gage height of 2.51 feet, gave a discharge of 1,123 second-feet; the second one, on June 27, at a gage height of 1.32 feet, gave a discharge of 290 second-feet; the third, on August 7, at a gage height of 0.88 foot, gave a discharge of 135 second-feet.

[1] Continued from Water-Supply and Irrigation Paper No. 35.

Daily gage height, in feet, of Roanoke River at Roanoke, Virginia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	2.25	3.20	2.00	1.43	1.15	1.00	0.90	0.75	0.65	1.20	0.80
2	1.80	2.20	2.95	1.88	1.40	1.20	1.05	.80	.85	.65	1.17	.80
3	1.75	2.05	2.85	1.79	1.39	1.18	1.03	.80	1.00	.65	1.25	.75
4	2.00	3.10	6.15	1.75	1.35	1.06	1.00	.70	.85	.65	1.30	.75
5	1.90	3.50	8.15	1.73	1.32	1.00	1.00	.70	.75	.65	1.10	.75
6	3.13	3.75	4.70	1.67	1.32	.98	1.00	.80	.75	.63	1.05	.75
7	5.85	4.08	3.68	1.62	1.41	.97	1.05	.90	.70	.60	1.00	.77
8	3.55	3.90	3.10	2.10	1.80	.95	.98	.85	.65	.85	.95	.80
9	2.90	3.85	3.00	1.90	2.03	.90	.93	.85	.70	.90	.90	.78
10	2.40	3.60	2.80	1.80	1.85	.95	.90	.85	.65	.80	.85	.75
11	2.50	3.50	2.70	1.75	1.76	1.00	.85	.75	.60	.85	.83	.75
12	2.40	2.45	a3.10	1.70	1.70	1.75	.82	.75	.57	.80	.80	1.50
13	2.30	2.25	a3.50	1.66	1.82	2.25	.80	.95	.70	.75	.80	1.55
14	2.80	a2.22	3.90	1.63	1.85	1.90	.80	1.00	.65	.70	.80	1.30
15	2.70	2.20	4.75	1.60	1.75	1.65	.95	1.00	.65	.70	.80	1.15
16	2.55	2.20	4.25	1.55	1.66	1.45	.83	.95	.65	.80	.78	1.05
17	2.45	3.55	3.70	1.52	1.57	1.30	.75	.90	.65	.77	.78	.95
18	2.30	3.25	3.45	1.47	1.46	1.18	1.05	.80	.65	.75	.75	.90
19	2.20	3.50	7.10	1.45	1.40	1.15	.90	.75	1.46	.73	.75	.90
20	2.15	3.95	4.90	1.40	1.31	1.10	.85	.72	2.05	.70	.73	.90
21	2.10	4.50	3.90	1.40	1.28	1.08	.82	.70	1.25	.70	.73	.88
22	2.07	4.40	3.55	1.37	1.25	1.05	.78	.67	1.00	.68	.70	.85
23	2.05	3.75	3.35	1.36	1.35	1.00	.80	.65	.85	.68	.75	.80
24	2.50	3.25	3.15	1.34	1.27	1.00	.85	.63	.80	.68	.75	1.10
25	2.25	2.90	3.00	1.38	1.20	1.10	.90	.60	.80	.68	.75	1.05
26	2.15	2.70	2.35	1.75	1.16	2.15	.85	.65	.75	.65	.73	.95
27	2.10	5.00	2.40	1.70	1.15	1.45	1.15	.75	.85	.65	.73	.90
28	2.05	3.65	2.45	1.60	1.13	1.15	1.00	.85	.75	.65	.75	1.25
29	a2.10	.....	2.30	1.50	1.10	1.05	.85	1.00	.70	.65	1.00	1.30
30	a2.20	.....	2.15	1.48	1.20	1.00	.82	.85	.65	.73	.85	1.45
31	2.25	.....	2.10	.....	1.13	.....	1.05	.80	.....	.80	.....	1.60

a Interpolated.

Main Roanoke River is formed by the junction of Dan and Staunton rivers at Clarksville, Virginia, and flows southerly, entering Albemarle Sound. The United States Weather Bureau has a station on Dan River at Danville, Virginia, 55 miles above the mouth of Staunton River. The gage is of timber, and is attached to the first pier of the iron bridge between North and South Danville. The highest water was 13.0, on September 13, 1893; lowest, 0.02, on January 26, 1894. The danger line is at 8 feet. The drainage area above the station is 1,900 square miles, according to the United States Weather Bureau.

A second gaging station is maintained by the United States Weather Bureau on Roanoke River at Clarksville, Virginia, 65 miles above Weldon, North Carolina. The river gage is on the south side of the river, attached to a tree leaning over the water. The highest recorded water was 13.5 feet, on September 14, 1893, and the lowest — 0.2 foot, on July 19, 1894. It is reported that on November 27, 1877, a height of 27 feet was reached. The danger line is at 12 feet. The drainage area above the station is 6,900 square miles, according to the United States Weather Bureau.

The third station maintained by the Weather Bureau on this river is erected at Weldon, North Carolina, 30 miles above Neal and 90 miles above Albemarle Sound. The river gage is located below the Atlantic Coast Line Railroad bridge, on the south side of the river. The gage is of white pine and is made of three sections, the lowest section, 4 feet to 17 feet, is of detached pieces fastened to trees which lean over the river; the second section, 17 feet to 47 feet, is attached to the fore bay of the Roanoke mills; above 47 feet the gage is painted

n the mill building. The zero of the gage is 4 feet below a large ock, known as "Big Cuba." It is 31 feet below the railroad crossing. he highest recorded water is 46.8 feet, on November 26, 1877; the owest, —0.3, on August 21, 1893. The danger line is at 27 feet. The rainage area above Weldon, according to the United States Weather Bureau, is 8,180 square miles.

ROANOKE RIVER AT NEAL, NORTH CAROLINA.

This station, described in the Eighteenth Annual Report, Part IV, page 47, was established July 27, 1896, and is on the Norfolk and Carolina Railroad bridge, near Neal, North Carolina. The bench marks for the gage rod are described in Water-Supply Paper No. 15, page 28. The length of the gage wire is 44.66 feet. The section is a fairly good one, the course of the river being straight for some distance above and below the station and the bottom smooth. Being muddy, however, the bed is apt to cut out in seasons of high water and both banks are subject to overflow. The observer is the bridge watchman, Mr. W. M. Adams, of Neal, North Carolina. Records of measurement may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 48; 1897, Nineteenth Annual Report, Part IV, page 181; 1898, Twentieth Annual Report, Part IV, page 142. The measurements made by E. W. Myers during 1899 are as follows:

February 5, gage height, 20.80 feet; discharge, 23,998 second-feet.
May 25, gage height, 6.41 feet; discharge, 6,045 second-feet.
June 7, gage height, 6.45 feet; discharge, 6,110 second-feet.
October 12, gage height, 8.60 feet; discharge, 7,973 second-feet.
November 28, gage height, 4.13 feet; discharge, 4,439 second-feet.

Daily gage height, in feet, of Roanoke River at Neal, North Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.40	9.10	22.80	20.60	10.50	8.10	8.40	7.30	11.00	3.60	4.30	4.00
2	7.60	10.20	23.40	19.10	9.50	10.30	7.20	6.50	8.20	3.00	10.50	4.20
3	10.50	10.70	22.80	17.40	9.00	12.20	5.70	5.90	5.70	2.70	12.30	4.30
4	14.20	11.00	21.80	16.00	9.10	12.60	4.70	5.10	4.10	2.50	12.00	4.20
5	13.10	20.75	22.70	15.20	9.00	10.50	4.20	3.80	3.90	2.30	13.40	4.10
6	11.35	22.35	24.00	14.90	8.80	8.30	4.20	3.50	5.70	2.80	14.15	3.95
7	10.80	23.95	25.25	15.00	8.70	6.50	4.60	3.60	5.00	5.30	12.10	3.80
8	17.25	25.55	26.08	17.70	8.60	5.40	7.10	4.20	4.00	6.90	9.50	3.50
9	23.25	26.80	26.10	21.40	8.70	4.90	11.10	5.60	3.10	7.80	7.60	3.30
10	25.50	27.05	25.10	23.00	8.90	4.60	11.20	6.70	2.70	9.10	6.30	3.20
11	27.75	26.40	23.20	23.60	10.80	5.00	9.80	6.20	3.70	9.90	5.50	3.10
12	26.80	24.50	21.20	22.30	11.30	8.10	7.50	5.00	5.80	8.70	5.10	3.20
13	24.55	21.30	19.20	20.20	13.00	17.80	5.50	5.40	6.00	6.90	4.60	3.50
14	22.25	17.50	17.60	18.30	12.60	21.50	4.20	7.30	5.50	5.50	4.30	7.00
15	21.80	14.30	17.70	16.80	11.90	22.40	3.50	5.40	4.30	4.50	4.10	11.50
16	21.00	12.50	22.80	15.40	11.40	22.40	3.20	4.50	3.40	3.90	4.00	11.50
17	19.05	12.90	23.80	14.30	10.40	21.00	3.10	6.50	2.90	3.60	3.90	9.20
18	18.00	19.50	25.70	13.40	9.20	18.10	3.30	10.90	2.40	3.45	3.80	7.20
19	16.90	19.60	26.80	12.60	8.10	15.20	3.40	9.20	2.10	3.30	3.70	6.00
20	15.80	24.70	26.10	11.90	7.50	12.40	4.20	7.20	2.00	3.25	3.60	5.10
21	14.40	26.80	26.10	11.40	7.10	10.20	4.50	5.40	2.00	3.00	3.50	4.70
22	13.20	27.25	27.80	10.50	6.90	8.60	4.80	4.30	11.25	3.20	3.40	4.40
23	12.20	26.90	30.00	10.00	6.60	7.30	3.90	3.30	14.00	2.90	3.35	4.30
24	11.30	26.20	29.35	9.70	6.30	6.30	3.80	2.80	10.60	2.80	3.35	4.45
25	10.80	25.20	27.40	9.40	6.40	5.20	4.70	2.40	7.55	2.70	3.60	6.40
26	10.30	23.60	25.50	9.10	6.90	4.80	4.80	2.10	5.40	2.60	3.80	8.40
27	10.10	22.00	22.80	9.40	7.00	4.40	7.20	1.80	4.70	2.60	4.00	8.60
28	9.90	21.80	20.70	11.80	6.40	4.30	7.30	1.60	4.90	2.60	4.10	8.10
29	8.70	.....	19.60	12.30	5.90	6.30	11.80	1.70	5.10	2.70	3.80	6.80
30	8.20	.....	20.10	11.60	5.60	6.70	11.90	13.70	4.60	2.70	3.70	5.60
31	8.60	.....	21.00	.....	5.90	.....	9.50	12.90	.....	3.00	.....	3.80

TAR RIVER AT TARBORO, NORTH CAROLINA.

Tar River rises in the north-central part of North Carolina and flows in a southeasterly direction into Pamlico River. It crosses the fall line at Rocky Mount, North Carolina, where is located the principal power on the river. The fall below this point is from 1 to 1½ feet per mile. The fall above this point is about 2 feet per mile, concentrated at a number of points where small powers can be developed. The drainage basin is largely covered with forest. The stream is subject to violent freshets and periods of very low flow. The gaging station, as described in the Eighteenth Annual Report, Part IV, page 50, is on the Atlantic Coast Line bridge, crossing the river at Tarboro, North Carolina, and was established by E. W. Myers on July 24, 1896. The length of the wire gage is 38.30 feet. The channel is straight, the current moderately swift, the banks low and flooded in high water. The bed is sandy and fairly constant. Sand bars slightly obstruct the flow of the river. The observer is R. H. Williams, who reads the gage once a day. Measurements of discharge are made at the highway bridge which crosses the stream about 200 yards above, this point furnishing a better station. Records of flow may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 52; 1897, Nineteenth Annual Report, Part IV, page 184; 1898, Twentieth Annual Report, Part IV, page 143. The following measurements were made by E. W. Myers during 1899:

February 5, gage height, 9.10 feet; discharge, 5,165 second-feet.
May 24, gage height, 2.60 feet; discharge, 1,125 second-feet.
June 7, gage height, 2.00 feet; discharge, 798 second-feet.
October 16, gage height, 2.95 feet; discharge, 1,150 second-feet.
November 28, gage height, 2.20 feet; discharge, 875 second-feet.

Daily gage height, in feet, of Tar River at Tarboro, North Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.20	6.30	15.00	8.60	4.60	2.40	1.00	10.00	0.60	1.70	4.30	3.70
2	3.10	7.20	14.80	7.80	4.10	3.50	1.00	10.60	.50	1.30	6.50	2.80
3	3.40	8.30	15.40	7.20	3.90	3.00	.95	9.60	.40	1.40	9.30	2.70
4	3.70	8.50	16.70	6.30	4.00	2.90	1.00	7.70	.30	.90	9.70	3.00
5	3.50	8.90	16.50	7.00	3.90	3.00	.95	5.50	.60	.80	6.50	3.20
6	3.30	12.50	17.80	8.00	3.80	2.50	.70	4.50	.50	1.40	5.70	2.80
7	3.40	15.70	18.30	8.90	3.60	2.00	3.20	4.00	.40	2.20	5.20	2.60
8	3.50	18.60	18.60	11.70	3.50	1.60	2.50	3.70	.50	7.00	4.60	2.50
9	3.40	21.90	18.40	14.50	3.60	1.50	2.00	4.50	.70	8.70	4.20	2.30
10	4.30	24.10	16.40	16.50	3.70	3.00	1.50	4.90	3.00	7.30	3.60	2.30
11	3.40	25.00	13.80	17.80	3.80	2.80	1.60	3.80	1.60	6.80	3.40	2.00
12	3.30	Ice.	11.10	18.30	3.60	2.50	2.50	3.10	3.60	6.00	3.00	2.20
13	3.70	Ice.	9.00	17.00	3.50	5.40	1.60	2.60	5.00	5.20	2.70	2.40
14	4.80	Ice.	8.20	14.40	4.30	7.60	1.40	3.00	3.30	4.30	2.60	3.00
15	6.80	14.75	9.80	10.70	4.00	9.30	1.10	4.10	2.10	3.50	2.40	3.70
16	8.80	11.70	13.80	8.00	4.30	10.60	1.00	3.80	1.60	3.00	2.30	3.50
17	10.30	11.80	16.70	7.00	3.70	9.50	.90	4.30	1.50	2.70	2.40	2.90
18	10.40	14.10	19.00	6.20	3.10	9.80	1.10	5.20	1.10	2.40	2.20	2.60
19	9.10	17.00	20.90	5.80	2.80	8.80	1.40	6.00	1.00	2.20	2.00	2.50
20	8.30	19.00	21.00	5.40	2.60	5.30	3.80	5.40	.80	2.00	1.80	2.40
21	7.00	22.00	19.70	5.50	2.80	3.70	3.20	4.80	.70	.80	2.10	2.30
22	5.90	23.00	17.50	5.30	2.60	3.00	2.30	4.20	.62	1.60	2.00	2.50
23	5.30	23.40	16.30	5.00	2.70	2.40	1.70	3.00	.50	1.50	1.90	2.10
24	4.90	23.10	13.70	4.60	2.70	2.00	1.30	2.80	.60	1.40	1.80	2.90
25	4.50	22.00	10.00	4.30	2.80	1.50	1.50	2.50	1.30	1.80	1.90	5.40
26	4.40	20.50	8.60	4.10	2.70	1.40	2.60	1.80	1.00	1.40	2.00	7.80
27	4.50	18.20	7.80	4.30	2.50	1.50	3.90	1.70	.50	1.30	1.90	8.50
28	4.70	16.30	7.50	5.40	2.30	1.40	6.90	1.50	3.50	1.10	2.20	6.80
29	4.10	.....	7.40	7.50	1.90	1.00	8.20	1.40	3.80	1.30	2.40	5.40
30	4.20	.....	7.90	6.20	2.10	.98	8.50	1.10	2.60	2.50	2.70	5.00
31	4.30	.....	8.50	.....	1.70	.....	9.45	.80	.....	3.20	.....	4.10

NEUSE RIVER AT SELMA, NORTH CAROLINA.

Neuse River rises in the north-central part of North Carolina, and ows in a southeasterly direction, emptying into Pamlico Sound. The tream crosses the fall line at Smithfield, below which point there is o power. The elevation of the river at Smithfield is about 106 feet. t the crossing of the Seaboard Air Line Railroad, some 35 miles above, he elevation is about 175 feet, making the fall in this part of the iver about 2 feet per mile. Above this point the fall is much greater. large part of the area drained by this stream is forest covered. The iver is subjected to violent freshets and to periods of low flow. The inimum flow per square mile decreases rapidly as the stream is scended. A weir measurement of Eno River where the drainage rea was about 100 square miles, gave a flow of 3,000,000 gallons per wenty-four hours, or 4.64 second-feet, or at the rate of 0.046 cubic feet er second per square mile. This measurement was made during the evere drought of the summer of 1897. There are a number of localties where power can be developed. The gaging station described in he Eighteenth Annual Report, Part IV, page 52, is located on the outhern Railway bridge, about 3 miles from Selma, North Carolina. t was established by E. W. Myers, July 29, 1896. The bed of the river ere is sandy and muddy and is liable to change in high water. The low is obstructed by one pier of the bridge; the channel is straight, the urrent moderately swift and confined to one channel. The gage rod was moved February 6, 1899, to the highway bridge, crossing the river bout 200 yards below. The zero of the gage rod is 33.7 feet west of the center rod of the truss of the bridge, and on the downstream side. The outer rim of the pulley wheel is 4.75 feet east of the zero of the gage rod, and the distance from the end of the weight to the marker on wire is 35.00 feet. When this station was visited on May 23, 1899, the gage was measured, and this distance was found to be 35.35 feet. When visited in June this length was found to be 35.37 feet; in October 35.48 feet, and at the November visit it was found to be 35.50 feet. This error has been allowed to accumulate, and gage heights on the attached sheet have been adjusted by these measurements. The observer is C. Richardson, engineer at pumping station, Selma, North Carolina. Records of flow may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 53; 1897, Nineteenth Annual Report, Part IV, page 186; 1898, Twentieth Annual Report, Part IV, page 144. The following measurements were made by E. W. Myers during 1899:

February 6, gage height, 15.68 feet; discharge, 7,807 second-feet.
May 23, gage height, 4.28 feet; discharge, 1,262 second-feet.
June 5, gage height, 3.10 feet; discharge, 773 second-feet.
October 12, gage height, 1.79 feet; discharge, 574 second-feet.
November 26, gage height, 1.30 feet; discharge, 356 second-feet.

Daily gage height, in feet, of Neuse River at Selma, North Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.40	6.50	22.30	4.70	1.94	4.44	1.22	10.60	0.95	1.45	10.50	1.10
2	1.30	5.90	22.00	4.00	1.60	3.56	1.25	9.50	.85	1.25	11.20	1.30
3	1.30	5.60	14.30	4.00	2.60	3.16	1.11	7.96	.75	1.02	11.40	1.00
4	2.00	6.00	15.40	5.70	2.00	3.26	1.11	6.10	.75	.72	11.20	1.40
5	2.50	12.30	18.20	6.20	2.10	3.11	1.22	2.16	.65	.52	4.20	1.20
6	2.00	13.40	17.90	6.40	2.36	2.60	1.32	2.20	.65	.42	4.30	1.30
7	2.10	19.90	17.47	9.77	2.40	1.61	1.46	2.00	.45	2.90	2.70	1.30
8	7.10	20.00	16.47	13.97	3.33	1.61	2.50	3.10	.55	6.82	2.30	1.20
9	6.50	20.90	13.97	10.67	3.47	2.63	3.00	3.67	.65	7.12	2.10	1.20
10	6.40	20.20	10.06	14.24	4.02	5.23	2.60	3.37	.55	7.42	2.10	1.20
11	5.50	18.97	8.56	11.70	4.77	7.03	2.40	3.47	.44	3.92	2.00	1.20
12	2.40	12.37	9.26	7.06	4.47	7.43	1.60	2.57	.84	2.72	1.50	1.40
13	1.20	10.36	9.15	4.96	3.76	3.73	1.40	2.47	.94	2.12	1.40	1.90
14	1.70	9.96	10.35	4.75	3.26	6.27	1.30	3.07	1.04	1.52	2.00	2.60
15	8.90	9.35	11.95	4.55	3.32	3.22	1.00	3.17	.94	1.32	2.00	3.20
16	8.90	6.45	18.05	4.54	4.46	2.42	1.00	2.57	.84	1.11	1.80	2.40
17	8.00	23.55	16.94	4.34	3.26	2.42	1.60	1.67	.74	.71	1.60	1.30
18	4.20	15.54	14.94	4.24	3.05	2.22	4.30	1.77	.64	1.01	1.50	1.20
19	3.20	17.34	18.23	4.03	4.70	2.02	5.30	1.47	.64	1.21	1.50	1.00
20	4.20	18.13	17.73	3.73	5.90	1.82	4.70	1.06	.74	1.31	1.50	1.00
21	3.20	18.73	12.53	3.63	5.35	1.72	2.70	.96	.64	1.31	1.40	1.50
22	2.40	17.02	9.82	3.52	4.80	1.62	2.30	.96	.63	1.31	1.30	1.90
23	2.50	17.32	8.02	3.32	4.40	1.32	1.50	.86	.73	1.31	1.20	3.00
24	2.50	15.32	6.82	3.12	3.74	1.42	1.20	.86	.83	1.11	1.10	3.00
25	2.40	14.22	5.41	3.21	3.44	1.42	3.50	.96	.83	1.01	1.00	2.20
26	3.10	15.51	5.21	3.41	2.94	1.32	6.50	.96	1.43	.80	1.00	1.90
27	3.10	15.20	5.11	4.21	2.44	1.32	10.10	.96	1.67	.70	.90	1.40
28	3.00	14.00	5.60	4.70	2.14	1.32	7.71	.96	2.53	.70	.80	1.20
29	2.30	.....	6.50	5.50	1.94	1.22	5.68	.86	2.87	.80	.70	1.20
30	2.40	.....	6.90	1.95	3.04	1.22	6.58	.96	1.53	.80	.70	1.20
31	2.40	.....	7.60	.....	5.04	.....	8.28	.95	.....	10.70	.....	1.30

HAW RIVER AT MONCURE, NORTH CAROLINA.

This station, established May 6, 1898, by E. W. Myers, is located 1¾ miles north of Moncure, Chatham County, North Carolina, at the bridge of the Seaboard Air Line, which crosses the river here, and about 2 miles from the junction of the river with Deep River to form the Cape Fear. The observer is M. A. Moore, Moncure, North Carolina, who also attends the station on Deep River. The gage is a horizontal rod well painted, divided into feet and tenths, securely nailed to the outer side of the guard rail of the bridge on the upstream side. The 2-foot mark on the rod is over the center of the second floor beam from the south end of the second span from the south end of the bridge. The length of gage was last verified November 26, 1899. The initial point for sounding is a notch cut in the guard rail opposite the south end of the bridge and on the upstream side, the section here being better than that on the downstream side. The channel is straight for some distance above and below the station. The velocity is good and uniformly distributed across the stream. Both banks are rather low and subject to overflow in time of flood. The bed of the stream is of coarse sand and gravel, and is probably not subject to any decided change in high water. The current here is somewhat modified by a fish dam about 150 yards above the bridge. The station is reached by private conveyance from Moncure. When the station was established in May, 1898, the distance from the end of the weight to the pointer on the wire was 43.45 feet. When it was visited in

August, 1898, the wire was measured and this distance was found to be 43.67 feet. In February, 1899, the gage was measured and found to be 43.75 feet. This length remained the same at the subsequent visits during the year, in June, October, and November. The error was not corrected on the gage at each visit, it being considered preferable to change the gage heights after the stretch was found to have become fixed. The gage heights for 1899, as published below, have been corrected. The following measurements were made during 1899 by E. W. Myers:

February 4, gage height, 8.96 feet; discharge, 5,594 second-feet.
May 26, gage height, 2.20 feet; discharge, 751 second-feet.
June 5, gage height, 2.99 feet; discharge, 1,275 second-feet.
October 12, gage height, 1.85 feet; discharge, 756 second-feet.
November 26, gage height, 1.37 feet; discharge, 358 second-feet.

Daily gage height, in feet, of Haw River at Moncure, North Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.03	4.98	15.70	5.54	2.94	2.62	1.43	4.16	1.07	1.04	10.53	1.28
2	3.68	4.48	9.06	4.68	2.70	2.60	1.31	3.42	.96	1.02	6.87	1.16
3	3.30	4.30	9.98	4.46	2.60	3.94	1.20	2.68	.91	.82	3.96	1.54
4	2.86	8.70	15.66	3.92	2.42	3.56	1.18	2.26	1.04	.82	4.61	1.52
5	2.84	16.40	18.48	3.86	2.38	2.98	7.90	1.48	1.02	.85	3.54	1.48
6	2.48	22.42	14.84	8.84	2.44	2.20	2.24	1.42	1.08	7.65	2.66	1.32
7	12.08	24.66	13.56	4.86	1.98	1.84	2.08	4.85	.98	5.62	2.09	1.30
8	10.32	26.13	9.41	11.12	7.86	1.62	2.22	4.92	.98	7.37	1.64	1.12
9	8.62	26.62	6.68	13.42	6.14	1.40	1.22	4.90	1.00	5.98	1.67	1.06
10	4.98	17.70	5.16	7.08	4.50	1.52	1.04	4.46	2.51	4.13	1.62	1.12
11	3.84	12.34	4.52	5.98	4.42	2.45	1.70	2.02	2.84	2.97	1.57	1.22
12	3.62	6.92	4.34	4.64	4.98	5.18	1.46	1.56	3.40	1.80	1.57	3.12
13	3.94	6.62	4.06	4.12	8.06	4.44	1.36	1.58	1.70	1.62	1.33	1.84
14	5.14	5.84	6.34	3.70	8.62	4.12	1.20	1.20	1.90	1.35	1.31	1.82
15	11.62	5.46	22.07	3.38	5.04	2.94	1.30	1.14	1.24	1.29	1.43	1.68
16	7.96	7.42	23.36	3.62	4.10	2.55	1.23	1.80	1.20	1.34	1.15	1.36
17	6.88	18.92	17.18	3.08	3.86	2.40	1.14	1.52	1.16	1.11	1.08	1.52
18	5.04	18.38	8.62	2.95	2.90	1.72	1.32	1.26	1.12	1.29	1.32	1.48
19	4.44	18.41	14.98	2.82	2.92	1.60	1.34	1.42	1.98	1.24	1.42	1.44
20	3.70	14.72	14.34	2.70	2.86	1.62	1.28	1.06	1.02	1.21	1.44	1.28
21	4.16	11.62	10.98	2.80	2.00	1.54	1.30	1.04	1.07	1.22	1.40	1.32
22	2.90	9.18	7.61	2.64	1.92	1.33	1.36	.92	1.46	1.20	1.38	1.26
23	2.98	8.26	5.44	3.44	2.94	1.59	1.34	.90	1.18	1.07	1.34	1.18
24	3.08	7.28	4.92	2.40	2.96	1.48	1.23	1.08	1.08	.94	1.26	1.54
25	3.16	5.40	4.72	2.42	2.62	1.36	1.28	1.08	2.04	.94	1.28	1.56
26	3.18	6.18	4.62	4.84	2.32	1.30	1.50	1.30	1.38	1.13	1.62	1.52
27	3.15	6.84	4.07	5.08	2.06	1.20	7.14	.92	1.24	1.17	1.98	1.38
28	3.10	13.58	6.34	4.10	1.90	1.38	6.30	1.00	1.08	1.04	2.84	1.32
29	2.50	.....	10.58	3.52	1.84	1.10	3.48	1.06	1.09	1.19	2.90	1.24
30	3.32	.....	7.46	2.98	2.20	1.54	2.02	1.40	.98	1.92	2.56	1.14
31	3.98	.....	6.34	.....	3.16	.....	5.68	1.18	.....	3.46	.....	2.38

DEEP RIVER AT MONCURE, NORTH CAROLINA.

This station, established May 5, 1898, by E. W. Myers, is located about one-fourth of a mile south of Moncure, Chatham County, North Carolina, at the covered wooden bridge of the Seaboard Air Line, which crosses the river here. It is about 2 miles above the junction with the Haw River to form the Cape Fear. The observer is M. A. Moore, of Moncure, North Carolina, a farmer and bridge watchman living about 100 yards from the bridge. The gage is a horizontal rod, well painted, divided into feet and tenths, and securely nailed to the guard rail of the bridge. The zero of the rod is 50 feet south of the

north end of the second span of the bridge from the north. The initial point of sounding is a notch cut in the guard rail opposite the south end of the bridge and on the downstream side. The channel is straight for some distance above and below the station. The banks are low and the bed probably slightly shifting during high water. The velocity is not great, but sufficient for proper measurement, and is well distributed across the stream. When the station was established on May 5, 1898, the distance from the end of the weight to the pointer on the wire was 45.16 feet. At every subsequent trip the gage wire has been measured, and it was discovered that the length was gradually increasing. When the station was visited on August 20, 1898, the length of the wire was found to be 45.27 feet. February, 1899, the length was found to be 45.38 feet; in May, 45.40 feet; in June, 45.45 feet; in October, 45.57 feet, and in November, 45.60 feet. These errors were allowed to accumulate to see if the wire had any definite fixed rate of stretch under a constant weight. The gage heights as published below have been adjusted from the measurements noted above. Records of flow may be found in the Twentieth Annual Report, Part IV, page 146. The following measurements were made during 1899 by E. W. Myers:

February 4, gage height, 7.03 feet; discharge, 4,590 second-feet.
May 27, gage height, 2.16 feet; discharge, 447 second-feet.
June 5, gage height, 2.51 feet; discharge, 610 second-feet.
October 12, gage height, 1.89 feet; discharge, 449 second-feet.
November 26, gage height, 1.32 feet; discharge, 290 second-feet.

Daily gage height, in feet, of Deep River at Moncure, North Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.03	4.58	6.91	7.12	2.99	2.84	1.52	4.54	0.85	0.83	12.74	2.77
2	3.21	5.00	6.25	4.70	2.85	2.61	1.36	4.36	.79	.78	5.86	1.85
3	3.41	6.78	6.39	4.52	2.56	3.45	1.34	3.46	.75	.88	4.23	1.83
4	3.27	7.06	13.25	5.16	2.51	3.13	1.18	3.08	.91	.79	3.48	2.19
5	2.79	16.40	14.43	8.64	2.29	2.49	4.20	1.46	.73	.87	3.04	2.15
6	2.47	20.48	15.77	6.18	2.25	1.95	2.42	1.20	.71	7.20	2.74	1.49
7	10.27	23.21	15.67	6.40	2.47	1.65	2.72	4.54	.89	6.49	2.24	1.27
8	9.13	25.92	13.62	17.76	8.85	1.49	2.11	4.11	1.19	6.70	1.91	1.19
9	7.71	20.96	10.61	15.04	6.09	1.58	2.19	4.15	1.10	7.11	1.86	1.11
10	5.59	18.70	7.39	8.28	4.43	2.55	2.10	3.37	1.82	3.96	.84	1.19
11	4.99	12.26	5.05	6.16	3.85	3.23	1.79	1.39	2.10	3.19	.89	4.03
12	5.83	7.19	4.41	5.40	5.89	4.72	1.67	1.41	2.55	1.97	1.09	5.95
13	6.07	6.98	4.67	4.86	7.99	3.78	1.34	1.25	2.04	1.72	1.02	4.69
14	9.79	6.06	3.91	4.48	9.23	3.40	1.19	1.21	4.86	1.59	1.09	3.39
15	13.07	5.10	21.19	3.76	5.99	2.56	1.09	1.29	1.96	1.31	.96	2.35
16	8.61	6.76	22.51	3.98	4.46	2.42	1.28	1.31	1.04	1.17	.98	1.39
17	7.91	16.20	16.21	4.10	3.97	2.40	.90	1.17	.93	1.27	1.08	1.34
18	6.93	21.26	9.99	4.04	3.75	1.68	1.14	1.09	.84	1.04	1.26	1.47
19	5.99	19.34	14.69	3.54	3.69	1.58	1.11	1.25	.87	1.06	1.14	1.39
20	4.73	15.30	15.31	3.32	3.05	1.49	1.02	.88	1.71	1.12	1.02	.63
21	3.15	9.92	9.02	3.46	2.89	1.50	1.02	.74	1.99	.97	.98	1.27
22	3.36	9.05	7.15	2.97	2.67	1.47	1.02	.78	1.49	.90	1.10	1.13
23	3.08	8.22	5.87	3.10	3.25	1.77	1.19	.90	1.17	.87	1.05	1.07
24	3.17	7.92	5.43	2.96	2.85	1.37	1.11	.95	.87	.85	1.04	1.19
25	3.25	6.24	4.91	2.97	2.75	1.55	1.52	1.06	2.34	.91	1.00	1.13
26	3.27	6.92	4.41	5.60	2.51	1.57	1.67	.84	1.53	.92	1.32	1.11
27	3.54	12.94	4.14	5.54	2.25	1.71	5.19	1.00	1.35	1.01	1.92	1.07
28	3.19	18.22	7.07	4.46	2.02	2.15	4.35	.96	1.09	.98	1.83	.95
29	2.55	.....	11.65	3.50	1.91	1.68	3.77	1.20	1.17	.94	3.78	1.03
30	2.21	.....	10.31	3.04	2.54	1.60	2.11	1.22	1.04	.89	2.84	.97
31	3.23	.....	8.44	.....	2.96	.....	6.28	.89	.....	1.13	.....	1.03

CAPE FEAR RIVER AT FAYETTEVILLE, NORTH CAROLINA.

Cape Fear River is formed by the junction of the Haw and Deep vers near Moncure, Chatham County, North Carolina, and flows in a utheasterly direction, emptying into the Atlantic Ocean near Wilington. Its watershed for the most part is flat and well covered ith forest growth. Measurements are made on both the Haw and e Deep at Moncure, and on the Cape Fear at Fayetteville. The easurements are of value in the study of the valuable water powers the Cape Fear and its tributaries. The gaging station described the Eighteenth Annual Report, Part IV, page 54, is at the bridge the Alantic Coast Line, about a mile east of Fayetteville, North arolina. The Weather Bureau has a gage fastened on the lower ide of the east abutment of the covered highway bridge, this being bout 400 feet above the railroad bridge, from which discharge measrements are made. The lower 29 feet of this gage consists of a rod livided into feet and tenths and firmly fastened to the abutment. Above the 29-foot mark the scale is painted on the rock. The observer s Frank Glover, who has charge of the steamboat landing just below he railroad bridge. For his convenience he has placed a subsidiary gage at the steamboat landing reading about the same as the official gage, and from this observations are taken. The channel is straight and the current moderately swift and not influenced by dams or other obstructions. The banks are high and the total flow of the river is n one channel, even during the highest floods. The bed is fairly onstant. Records of flow may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 56; 1897, Nineteenth Annual Report, Part IV, page 93; 1898, Twentieth Annual Report, Part IV, page 145. The following measurements were made by E. W. Myers during 1899:

February 7, gage height, 46.50 feet; discharge, 61,921 second-feet.
May 24, gage height, 6.40 feet; discharge, 3,142 second-feet.
June 6, gage height, 4.20 feet; discharge, 1,577 second-feet.
October 13, gage height, 6.00 feet; discharge, 2,132 second-feet.
November 29, gage height, 9.65 feet; discharge, 7,742 second-feet.

Daily gage height, in feet, of Cape Fear River at Fayetteville, North Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.50	11.00	30.80	17.80	7.20	6.00	2.90	11.50	2.40	2.00	11.00	8.00
2	4.60	18.10	25.00	17.00	6.00	6.40	6.40	10.00	2.20	1.70	21.40	6.40
3	6.50	14.00	21.00	14.00	6.00	8.00	8.00	8.80	1.90	1.70	17.50	6.50
4	6.50	12.80	28.60	12.20	5.50	7.60	7.60	7.00	1.60	1.50	12.80	7.00
5	5.80	23.00	34.40	15.60	5.50	6.10	6.10	5.50	1.50	1.40	10.40	6.70
6	5.50	31.90	33.20	21.00	5.50	4.20	4.20	4.20	1.60	2.10	8.30	5.50
7	5.50	41.00	27.40	17.60	5.60	4.20	4.20	3.20	1.40	14.40	6.50	5.10
8	17.00	50.80	25.00	23.20	8.60	3.80	3.80	2.60	2.00	13.50	5.00	4.90
9	21.40	52.00	20.00	35.50	14.20	3.50	8.30	7.00	1.80	17.00	5.00	4.70
10	14.90	47.30	15.00	30.30	13.00	4.50	9.30	10.20	1.90	13.20	5.00	4.30
11	10.20	37.40	11.50	23.00	9.80	7.50	6.40	7.00	1.80	10.00	4.80	4.30
12	8.00	30.00	10.20	19.40	10.90	8.10	5.00	5.50	5.70	7.00	4.50	4.50
13	9.30	20.80	9.40	15.80	11.00	10.00	3.60	4.60	4.00	5.00	4.60	4.00
14	10.00	12.30	8.70	13.50	15.40	11.10	3.10	3.70	4.00	4.50	4.30	14.00
15	19.00	10.00	18.60	10.20	17.30	8.00	2.60	3.00	4.60	3.80	4.00	10.00
16	23.60	12.50	38.60	9.80	12.00	5.80	2.40	2.70	4.00	3.50	4.00	7.50
17	17.20	24.00	42.00	9.00	9.70	5.00	2.40	2.50	2.50	3.50	4.00	6.00
18	14.50	36.50	38.00	10.00	7.20	4.60	4.50	2.40	1.80	3.00	3.90	5.40
19	13.40	42.60	28.00	9.20	5.50	4.10	4.00	2.70	1.60	3.30	3.80	5.00
20	11.00	43.00	28.80	9.40	5.30	3.70	3.50	2.70	1.80	3.00	3.60	4.80
21	9.20	38.50	32.00	9.00	5.20	3.20	3.00	2.30	2.50	2.70	3.50	4.50
22	8.00	34.00	25.00	8.50	5.00	3.20	2.40	2.20	4.00	2.50	3.30	4.00
23	7.00	28.30	18.00	8.40	5.30	3.00	2.30	5.00	3.70	2.20	3.30	4.20
24	6.20	23.00	14.70	8.00	6.30	3.10	2.80	3.70	3.20	2.30	3.80	5.40
25	6.20	18.20	12.00	6.60	6.00	2.90	4.00	2.50	2.60	2.10	4.00	10.00
26	6.00	16.40	10.00	7.00	5.50	2.50	6.40	2.70	2.90	2.10	4.00	12.00
27	7.00	17.00	10.00	10.00	5.30	2.80	7.00	2.10	3.70	2.10	4.50	9.70
28	6.80	28.40	12.00	11.40	4.70	3.10	12.80	1.60	3.90	2.10	5.60	7.30
29	6.60	.....	17.80	10.00	4.20	3.50	11.70	1.60	3.00	2.10	10.00	6.00
30	6.60	.....	21.70	8.80	4.20	3.20	9.90	1.50	2.50	2.10	9.50	5.90
31	7.00	.....	19.20	.....	5.00	.....	7.60	2.90	.....	4.20	.....	.....

YADKIN RIVER AT SALISBURY, NORTH CAROLINA.

This river rises in the west-central part of North Carolina, flows easterly, and then turning abruptly south continues across the central part of North Carolina and through the northeastern part of South Carolina into the Atlantic Ocean. Throughout the upper part of its course the topography of its watershed is rough and mountainous, but as it approaches the ocean the land becomes flat and marshy. The upper portion of its watershed is well timbered. The drainage area is partly mapped on the Statesville, Hickory, Wilkesboro, Yadkinville, and Hillsville atlas sheets. There are a number of places where water powers may be developed, and measurements have been made to determine the available amount. A station has been established near Salisbury, North Carolina, and another one about 50 miles nearer its mouth, at Norwood, North Carolina. The Salisbury station, described in the Eighteenth Annual Report, Part IV, page 57, was established by C. C. Babb September 24, 1895, and is located at the Southern Railway bridge near Holtsburg, near the mouth of Grant Creek, and about 6 miles from Salisbury, North Carolina. The length of the wire gage is 55.10 feet. The observer is W. L. Owen, fireman of pumping station, located just below the bridge. The station is easily reached by private conveyance from Salisbury. Discharge measurements are made from the lower side of the deck bridge, the zero point *being on the* left bank. The channel is obstructed by three piers

ith large rafts of driftwood lodged against each and sand bars elow each. The channel is straight, current swift, and the bed ough and rocky. The banks are rather low, but all of the water asses beneath the bridge during floods. Records of discharge may e found as follows: 1896, Eighteenth Annual Report, Part IV, page 9; 1897, Nineteenth Annual Report, Part IV, page 201; 1898, Twenieth Annual Report, Part IV, page 146. The following measureients were made by E. W. Myers during 1899:

Measurements of Yadkin River at Salisbury, North Carolina.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
February 9	6.60	14,781	June 9	2.38	4,264
March 20	18.80	115,085	October 4	1.70	1,847
April 14	3.75	8,795	November 24	1.70	1,957
June 8	2.30	4,264	December 14	3.00	5,952

aily gage height, in feet, of Yadkin River at Salisbury, North Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.00	3.20	4.70	4.30	3.10	2.40	2.20	2.80	2.00	1.60	2.00	1.90
2	2.00	3.00	4.00	3.90	3.10	2.90	2.10	2.30	2.10	1.60	2.20	1.90
3	2.10	2.90	6.10	3.80	3.10	2.60	2.10	2.20	2.20	1.60	2.20	1.90
4	2.00	2.90	8.00	4.10	3.10	2.60	2.50	2.00	2.10	1.60	2.40	1.80
5	3.10	7.50	8.00	4.20	3.00	2.50	3.20	2.00	2.10	1.70	2.20	1.80
6	4.00	8.75	7.15	4.70	2.90	2.40	2.50	1.80	1.90	1.70	2.00	1.80
7	10.20	10.10	5.90	4.80	3.20	2.40	2.30	1.80	1.80	1.80	1.90	1.80
8	5.90	9.20	4.10	7.80	4.40	2.40	2.30	2.30	1.70	2.90	1.90	1.70
9	4.80	6.30	3.90	5.90	4.00	2.40	2.20	2.10	1.70	3.00	1.80	1.70
10	4.00	4.00	3.70	4.70	3.50	3.10	2.20	2.00	2.20	2.40	1.70	1.70
11	3.00	3.30	3.50	4.20	3.40	3.30	2.10	2.00	2.00	2.10	1.70	1.70
12	4.40	3.40	3.40	3.80	3.30	3.80	2.10	1.90	1.90	1.90	1.70	2.00
13	4.00	2.90	3.30	3.80	4.10	4.80	2.00	2.10	1.90	1.90	1.70	3.80
14	4.50	2.90	5.20	3.80	4.10	3.90	2.00	2.00	1.70	2.00	1.70	3.40
15	4.40	2.20	8.50	3.70	3.60	3.20	1.90	1.90	1.70	1.90	1.70	2.90
16	4.10	3.00	12.40	3.70	3.10	2.60	1.90	1.90	1.60	1.80	1.70	2.10
17	3.70	5.10	7.90	3.60	3.00	2.50	1.90	1.80	1.60	1.80	1.70	2.00
18	3.50	6.00	6.70	3.50	3.00	2.40	2.30	1.70	1.60	1.80	1.70	1.90
19	3.20	5.00	12.00	3.40	2.90	2.40	2.20	1.70	1.50	1.80	1.70	1.90
20	3.10	4.60	17.80	3.40	2.80	2.30	2.10	1.80	4.20	1.80	1.70	1.90
21	2.80	4.00	13.75	3.40	2.70	2.30	1.90	1.60	2.90	1.80	1.70	1.70
22	2.90	3.90	6.50	3.30	2.70	2.30	1.90	1.60	2.20	1.80	1.70	1.70
23	2.80	3.60	5.30	3.20	2.90	2.30	1.90	1.60	1.90	1.70	1.70	1.70
24	2.90	3.10	4.80	3.20	3.00	2.20	1.90	1.50	1.70	1.70	1.70	2.00
25	2.80	3.10	4.40	3.30	2.80	2.20	2.00	1.50	1.70	1.70	1.70	2.40
26	2.80	3.00	4.30	4.10	2.70	2.80	2.70	1.50	1.70	1.70	1.70	2.40
27	2.80	5.40	5.40	4.10	2.70	3.00	4.30	1.60	1.70	1.70	1.80	2.10
28	2.90	7.80	5.40	3.80	2.60	2.00	3.20	2.00	1.60	1.70	1.80	1.90
29	2.80	.....	6.30	3.40	2.60	2.40	3.00	2.20	1.60	1.70	1.90	1.80
30	2.70	.....	5.30	3.30	2.60	2.20	2.80	2.20	1.50	1.70	1.90	1.80
31	3.30	.....	4.50	.....	2.50	.....	3.50	1.90	.....	1.70	.....	1.70

Yadkin River, after passing the State line into South Carolina, is nown as Pedee River. The United States Weather Bureau has aintained a station at Cheraw, South Carolina, on Pedee River. The age is a pine timber attached to the Cheraw toll bridge. The top f the rail on the Cheraw and Darlington Railroad bridge is 58 feet bove zero of gage. The highest water was 37.3 feet on March 11, 875; lowest, 0.0 feet, in August, 1866. The danger line is at 27 feet. The drainage area at this point is 6,960 square miles, according to

the United States Weather Bureau. The second river-height station maintained by the United States Weather Bureau at Smiths Mills, South Carolina, is 100 miles below Cheraw and 45 miles above the mouth of the river. The gage is a 1 by 6 inch pine timber attached to the central front wooden pier of the E. P. Smith wharf. The zero of the gage is 25 feet below the doorsill of the house adjoining the wharf. The highest water was 16 feet in September, 1893; the lowest, —0.4 foot, on October 22, 1895. The danger line is at 16 feet.

YADKIN RIVER AT NORWOOD, NORTH CAROLINA.

This station, described in the Eighteenth Annual Report, Part IV, page 60, was established by E. W. Myers September 1, 1896. It is at Blalocks Ferry, 1 mile above Richland Creek and about 2 miles from Norwood, North Carolina. The gage is a vertical rod divided into feet and tenths, and is securely spiked and braced to an overhanging tree near the ferry. The rod is referred to a bench mark consisting of a large nail driven into the root of a birch tree about 50 feet northwest of the rod. The zero of the gage rod is 5.93 feet below the bench mark. The river here is broad and shallow with smooth bottom of sand and gravel, giving a good section for discharge measurements, which are taken from the ferryboat. The channel is straight and free from all obstructions. The current is swift and the depth of the water uniform, except at a point about 100 feet from the right bank where the water is deep and very sluggish. The banks are low, and at the time of highest flood are overflowed for a distance of half a mile. The observer is W. B. Nichols, of Norwood, North Carolina, a farmer, who also carries the mail. Records of discharge may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 61; 1897, Nineteenth Annual Report, Part IV, page 203; 1898, Twentieth Annual Report, Part IV, page 147. Measurements made by E. W. Myers during 1899 are as follows:

April 9, gage height, 3.40 feet; discharge, 10,581 second-feet.
June 8, gage height, 1.95 feet; discharge, 4,474 second-feet.
June 9, gage height, 1.95 feet; discharge, 4,474 second-feet.
October 6, gage height, 1.35 feet; discharge, 2,629 second-feet.
October 6, gage height, 1.33 feet; discharge, 2,619 second-feet.
December 15, gage height, 2.23 feet; discharge, 6,299 second-feet.

The following table, computed by E. W. Myers, shows the comparative run-off of the Yadkin River at Salisbury and Norwood. At the former point the area drained is 3,399 square miles, and at the latter station 4,614 square miles. The table is of interest on account of the close results, especially in the run-off of second-feet per square mile between the two stations, which are about 50 miles apart and have a difference in drainage area of 1,215 square miles. The footnotes at the bottom of the table should be studied in the same connection, as

the two stations were not established at the same time, and in the first part of the record are not entirely comparable. The table should be compared with a similar table for the Catawba River at Catawba and Rock Hill stations, given on page 122.

Table showing comparative minimum flows for Yadkin River at Salisbury and Norwood, North Carolina.

Year.	Driest month.		Mean flow for driest month.		Mean flow for driest month per square mile.		Minimum flow for year.		Minimum flow for year per square mile.	
	Salisbury.	Norwood.	Salisbury.	Norwood.	Salisbury.	Norwood.	Salisbury.	Norwood.	Salisbury.	Norwood.
			Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec. ft.*	*Sec.-ft.*
1895	Oct.	(a)	1.426	(a)	0.42	(a)	1.400	(a)	0.41	(a)
1896	Aug.	Sept. b	2.411	b 2.409	.71	b 0.52	1.000	b 1.450	.29	b 0.31
1897	Sept.	Sept.	1.727	1.822	.51	.39	900	1.310	.26	.28
1898	June	June	1.832	2.623	.54	.57	1.100	c 1.380	.32	.30
1899	Sept. d	Oct.	2.332	2.836	.69	.61	1.300	1.790	.38	.39

a Station not established during this year.

b Not directly comparable. Station not established until September.

c Minimum flow not in month of lowest mean flow, but in July.

d Figures for Norwood station for September are as follows: Mean flow, 3,346 cubic feet per second, 0.725 second-feet per square mile; minimum flow, 2,080 second-feet, 0.451 second-feet per square mile.

NOTE.—For 1897, where the difference is most marked, there is a higher stage of water reported from the Salisbury station than at the Norwood station, the crest of the flood probably passing the latter station at night. Had this been noted, it would further increase the mean flow for this station.

Daily gage height, in feet, of Yadkin River at Norwood, North Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	3.00	4.50	.....	2.60	2.10	1.90	2.70	1.50	1.30	1.70	1.20
2	4.30	2.90	3.70	.....	2.50	2.20	1.80	2.20	1.70	1.20	1.90	1.20
3	3.30	2.50	4.30	.....	2.70	2.50	1.70	2.70	1.20	1.20	1.80	1.50
4	2.30	2.70	6.70	.....	2.60	2.10	1.70	1.70	1.80	1.20	1.70	1.50
5	2.50	8.00	7.50	.....	2.50	2.10	3.00	1.20	1.80	1.10	1.90	1.50
6	2.40	10.50	6.10	.....	2.40	2.00	3.00	1.60	1.70	1.30	1.80	1.40
7	7.80	10.20	4.10	.....	2.60	2.00	2.20	1.50	1.50	1.40	1.70	1.40
8	9.00	9.60	4.00	.....	3.20	1.90	2.00	1.50	1.40	2.00	1.70	1.30
9	7.00	7.40	3.80	3.40	3.50	2.00	2.00	1.80	1.80	2.20	1.80	1.30
10	3.80	4.60	3.40	3.00	3.00	2.10	1.90	1.70	1.70	2.40	1.40	1.40
11	3.10	3.20	2.00	2.90	3.00	3.40	1.90	1.60	1.90	2.10	1.40	1.40
12	3.00	3.10	2.10	2.80	2.80	3.50	1.60	1.50	1.70	1.70	1.40	2.40
13	2.90	3.00	2.40	2.80	4.50	3.40	1.60	1.80	1.50	1.40	1.40	3.10
14	4.20	2.40	3.10	2.70	4.00	3.80	1.60	1.70	1.60	1.30	1.40	3.10
15	4.50	2.30	8.10	2.70	3.50	3.00	1.50	1.60	1.50	1.50	1.40	2.40
16	3.90	5.60	10.40	3.40	2.80	2.50	1.50	1.50	1.40	1.50	1.40	2.10
17	3.80	5.80	10.30	3.00	2.50	2.20	1.50	1.50	1.20	1.50	1.30	1.80
18	3.30	6.90	8.80	2.80	2.40	2.10	1.60	1.40	1.50	1.40	1.30	1.30
19	3.10	5.60	(a)	2.80	2.20	2.00	1.80	1.40	1.30	1.40	1.20	1.20
20	2.80	5.00	.....	2.70	2.50	2.00	1.50	1.30	1.20	1.40	1.30	1.20
21	2.60	4.20	.....	2.70	2.30	1.90	1.50	1.30	3.00	1.40	1.40	1.50
22	2.50	3.60	.....	2.50	2.20	1.90	1.40	1.40	2.80	1.30	1.30	1.50
23	2.40	3.60	.....	2.50	2.40	1.90	1.40	1.30	1.70	1.30	1.40	1.50
24	2.30	3.40	.....	2.40	2.60	1.80	1.50	1.20	1.70	1.20	1.40	1.80
25	2.50	2.90	.....	2.30	2.50	1.70	1.70	1.20	1.40	1.30	1.30	2.10
26	2.40	3.80	.....	2.80	2.30	1.70	1.60	1.20	1.30	1.20	1.30	2.10
27	2.40	5.80	.....	3.50	2.20	2.40	4.00	1.20	1.30	1.20	1.30	1.70
28	2.30	7.60	.....	3.10	2.10	2.30	2.00	1.20	1.40	1.20	1.50	1.80
29	2.30	.....	.....	2.80	2.10	2.10	2.50	1.60	1.30	1.20	1.70	1.20
30	2.20	.....	.....	2.70	2.20	2.00	2.30	1.80	1.20	1.20	1.70	1.20
31	2.70	.....	.....	.....	2.20	.....	2.10	2.00	.....	1.70	.....	.....

a No readings March 19 to April 8; gage washed out by flood.

CATAWBA RIVER AT CATAWBA, NORTH CAROLINA.

This river rises in the west-central part of North Carolina and flows in a general southerly direction into South Carolina, where it empties into Santee River. At a number of points along this river there are water powers which may be developed. Near its source Catawba River flows through a mountainous country, which becomes flatter as the South Carolina line is approached. The greater part of its watershed is covered with woodland or forest. The drainage area above Catawba is entirely mapped on the Hickory, Morganton, Wilkesboro, Mount Mitchell, and Cranberry atlas sheets. Systematic measurements have been made on the Catawba at Catawba, North Carolina, and near Rockhill, South Carolina. The station at Catawba, as described in the Eighteenth Annual Report, Part IV, page 64, was established by E. W. Myers, July 4, 1896, at the Southern Railway bridge, about one-half mile from Catawba, North Carolina. The river is straight for several miles above and below the bridge; the current is swift and evenly distributed across the stream. The channel is obstructed by three piers, riprap, and two trestles of false work. At time of highest water the west bank overflows slightly and the sandy bed cuts out in places. The observer is C. A. Reed, jr., a clerk in the post-office at Catawba, North Carolina. Discharge measurements are made from the plank walk underneath the bridge. The railway bridge here is a deck bridge, and the gage was located on a footway which was laid along the lower system of bracing. When the station was visited, in October, 1899, it was discovered that the span on which the gage was located was to be removed, so it became necessary to move the gage rod, which was done as follows:

A small temporary gage was installed to discover any change in the stage of the river while the gage was being removed. The distance from the weight to the pointer on the wire was measured and found to be correct when the gage-reading was taken and recorded, as was also the reading of the temporary gage. The rod was then moved to the position which was chosen for it, and securely fastened to the guard rail on the downstream side and on the second span of the bridge from the west. The zero of the rod is over the center of the second floor beam from the west end of the second span from the west end of the bridge. From the zero of the rod to the outer rim of the pulley wheel is 2.6 feet. The small temporary gage was then read and it was found that the reading was unchanged, so the gage in its new position was given the same reading as it had before. The length of the wire rope from the end of the weight to the pointer on the wire was then measured and found to be 55.25 feet. Records may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 65; 1897, Nineteenth Annual Report, Part IV, page 214; 1898, Twentieth

Annual Report, Part IV, page 149. The following measurements were made by E. W. Myers during 1899:

February 24, gage height, 3.26 feet; discharge, 3,598 second-feet.
February 24, gage height, 3.28 feet; discharge, 3,690 second-feet.
June 10, gage height, 2.94 feet; discharge, 2,820 second-feet.
October 9, gage height, 2.36 feet; discharge, 1,716 second-feet.
November 23, gage height, 2.20 feet; discharge, 1,118 second-feet.
December 16, gage height, 2.66 feet; discharge, 2,153 second-feet.

Daily gage height, in feet, of Catawba River at Catawba, North Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.50	2.70	5.45	4.65	3.40	2.95	2.40	2.20	2.40	1.95	2.10	2.10
2	3.10	2.70	4.30	4.40	3.40	2.00	2.35	2.25	2.90	1.95	2.15	2.15
3	3.00	2.80	4.00	3.90	3.35	2.90	2.30	2.20	2.75	1.95	2.10	2.15
4	2.80	10.00	4.00	3.95	3.30	2.80	2.30	2.15	2.60	1.90	2.15	2.15
5	2.80	8.60	7.40	4.60	3.30	2.75	2.35	2.10	2.40	1.90	2.20	2.15
6	5.20	9.60	5.90	4.40	3.25	2.70	2.40	2.10	2.20	2.00	2.18	2.15
7	8.90	9.10	4.30	5.70	4.90	2.65	2.50	2.30	2.20	2.10	2.18	2.10
8	4.70	6.50	4.15	8.90	4.70	2.60	2.60	2.40	2.25	2.20	2.15	2.10
9	4.40	5.60	4.00	5.75	4.25	3.35	2.50	2.35	2.30	2.36	2.10	2.10
10	4.00	4.30	3.80	5.10	3.85	2.92	2.40	2.80	2.50	2.30	2.10	2.10
11	3.90	3.60	3.70	4.50	3.60	2.90	2.40	2.60	2.40	2.25	2.10	2.15
12	3.90	3.30	3.60	4.30	3.75	3.35	2.35	2.40	2.20	2.20	2.10	6.50
13	3.80	2.90	3.55	4.10	5.10	3.25	2.30	2.40	2.00	2.18	2.10	6.10
14	3.50	2.90	3.50	4.00	3.80	3.15	2.20	2.00	2.00	2.15	2.10	3.30
15	3.80	2.90	16.50	3.90	3.60	3.05	2.20	2.10	2.00	2.10	2.10	2.90
16	3.60	4.20	11.10	3.80	3.40	2.95	2.20	2.00	2.00	2.05	2.10	2.60
17	3.30	7.30	6.70	3.70	3.20	2.90	2.20	2.00	2.00	2.05	2.05	2.55
18	3.10	5.00	6.80	3.60	3.05	2.90	2.25	2.00	2.00	2.05	2.05	2.50
19	3.00	4.30	22.80	3.50	3.00	2.80	2.20	2.00	2.85	2.10	2.05	2.50
20	2.90	4.00	15.80	3.50	2.95	2.70	2.18	2.00	2.30	2.10	2.05	2.45
21	2.80	3.75	7.30	3.50	2.90	2.60	2.15	2.00	2.15	2.10	2.00	2.35
22	2.70	3.50	6.90	3.50	2.95	2.50	2.15	2.00	2.00	2.10	2.00	2.25
23	2.70	3.40	5.90	3.50	3.00	2.40	2.15	2.00	2.00	2.10	2.00	3.00
24	2.70	3.25	5.30	3.50	2.90	2.30	2.15	2.00	2.00	2.10	2.00	3.10
25	3.00	3.20	4.80	3.70	2.85	2.30	2.15	2.05	2.00	2.08	2.00	3.10
26	2.85	3.70	4.70	4.50	2.80	2.60	3.70	2.03	1.95	2.08	2.05	3.08
27	2.70	13.30	6.50	4.25	2.80	2.50	3.30	2.05	1.95	2.05	2.05	3.05
28	2.70	6.00	6.50	3.60	2.80	2.40	2.70	2.10	2.00	2.05	2.05	3.05
29	2.70	.....	6.00	3.40	2.80	2.40	2.40	2.25	2.00	2.03	2.10	3.00
30	2.70	.....	5.50	3.80	2.80	2.40	2.35	2.35	1.95	2.00	2.10	3.50
31	2.70	.....	5.00	.....	2.80	.....	2.30	4.00	.....	2.05	.....	3.65

CATAWBA RIVER AT ROCKHILL, SOUTH CAROLINA.

This station, described in the Eighteenth Annual Report, Part IV, page 61, was established by C. C. Babb September 3, 1895. It is located at the bridge of the Southern Railway, 3 miles south of Fort Mill, South Carolina, and is about 60 miles below the Catawba station. The gage is fastened to the upper side of the guard rail, the 2-foot mark of the rod being over the center of the second vertical of the second truss from the south end of the bridge. The bench mark is described in Water-Supply Paper No. 15, page 35. The length of the gage was verified December 18, 1899, when it was found to have stretched 0.4 foot. The gage heights as published are corrected for this error. This station is reached from Rockhill by private conveyance. The channel is straight, current swift, and flow uninterrupted. The banks are not subject to overflow and all of the water is confined to one channel. The bed of the stream is solid rock and very rough. The current is at an angle with the bridge. Altogether the section

is a poor one. W. A. Morris, a farmer at Rockhill, is the observer. Records of flow can be found as follows: 1896, Eighteenth Annual Report, Part IV, page 63; 1897, Nineteenth Annual Report, Part IV, page 214; 1898, Twentieth Annual Report, Part IV, page 150. The following measurements were made by E. W. Myers during 1899:

February 23, gage height, 3.10 feet; discharge, 8,086 second-feet.
June 13, gage height, 2.45 feet; discharge, 6,065 second-feet.
October 3, gage height, 1.60 feet; discharge, 2,104 second-feet.
December 18, gage height, 2.00 feet; discharge, 2,848 second-feet.

The table below was computed by E. W. Myers, and shows the comparative minimum flows of Catawba River at Catawba and Rockhill stations, which are about 60 miles apart. The drainage area at Catawba, North Carolina, is 1,535 square miles, and at the lower point, or Rockhill, South Carolina, it is 2,987 square miles. This table is comparable with the one for Yadkin River, shown on page 119, and it will be seen that the run-off per square mile does not vary to any greater extent than one would expect. The Catawba station was not established until the year following the one at Rockhill, so that the results can not be compared in the early part of the record. These facts are brought out in the footnotes at the bottom of the tables.

Table showing the comparative minimum flows for Catawba River, Catawba and Rockhill stations.

Year.	Driest month.		Mean flow for driest month.		Mean flow, driest month, per square mile.		Minimum flow for year.		Minimum flow for year per square mile.	
	Rockhill.	Catawba.	Rockhill.	Catawba.	Rockhill.	Catawba.	Rockhill.	Catawba.	Rockhill.	Catawba.
			Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
1895	Sept.*a*	.....	1,318	.....	0.441	.....	1,300	.....	0.435	.....
1896	Aug	Oct	1,604	865	.54	0.56	*b*1,330	770	.445	0.501
1897	Sept	Sept	1,817	1,017	.61	.66	*c*1,575	*d*850	.526	.553
1898	June	June	2,091	1,069	.70	.69	1,600	910	.535	.592
1899	Nov	Nov	2,492	1,340	.835	.873	2,300	1,220	.770	.793

a Seven days' record.
b Also in July, August, and September.
c Minimum occurred in January. September minimum was 1,700 second-feet, or 0.569 second-foot per square mile.
d Minimum in October. September minimum 900 second-feet, or 0.579 second-foot per square mile.

ge height, in feet, of Catawba River at Rockhill, South Carolina, for 1899.

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
2.20	2.40	6.20	4.00	2.80	2.20	2.10	2.10	2.00	1.70	1.90	1.70
2.80	2.50	4.10	3.70	2.80	2.20	2.00	2.00	3.50	1.60	1.80	1.70
2.60	2.30	3.40	3.40	2.70	2.40	2.00	1.90	2.50	1.60	1.70	1.60
2.30	2.30	3.40	3.25	2.70	2.40	1.85	1.90	2.10	1.60	2.10	1.60
2.30	7.90	4.80	4.30	2.60	2.25	1.80	1.90	2.10	1.50	1.80	1.60
2.20	10.75	4.10	4.20	2.60	2.20	1.80	1.80	2.00	1.50	1.70	1.60
8.30	11.70	4.30	3.80	2.60	2.20	1.80	1.70	2.00	1.80	1.60	1.60
8.00	10.20	3.70	6.20	3.30	2.15	1.90	1.70	2.60	2.40	1.60	1.60
5.10	6.20	3.20	6.90	3.80	2.10	2.00	1.80	1.90	2.10	1.60	1.00
3.30	4.20	3.10	4.80	3.10	2.10	2.00	2.00	2.30	1.80	1.60	1.70
2.80	3.50	2.90	4.00	2.90	2.50	1.90	2.20	2.60	1.80	1.60	1.60
2.85	3.10	2.90	3.70	2.80	2.50	1.90	2.40	2.10	1.70	1.60	2.80
2.70	2.80	2.80	3.50	2.70	2.40	1.80	2.20	1.80	1.70	1.60	3.30
3.10	2.50	2.60	3.40	4.30	2.90	1.80	1.90	1.80	1.70	1.60	3.00
3.60	2.60	7.55	3.30	3.40	2.60	1.80	1.80	1.80	1.70	1.60	2.60
3.30	3.10	14.05	3.15	2.90	2.35	1.80	1.80	1.70	1.70	1.60	2.20
2.95	5.80	12.00	3.20	2.70	2.20	1.80	1.80	1.70	1.70	1.60	2.10
2.80	6.60	5.70	3.10	2.60	2.05	1.80	1.80	1.55	1.70	1.50	2.00
2.70	4.80	5.30	3.10	2.55	2.05	1.80	1.80	1.50	1.70	1.50	2.20
2.60	3.90	16.85	3.00	2.55	2.05	1.80	1.70	1.80	1.70	1.50	2.10
2.50	3.40	14.20	2.90	2.50	2.00	2.10	1.70	2.00	1.70	1.50	2.10
2.40	3.30	5.70	2.85	2.40	2.00	1.80	1.60	1.90	1.70	1.50	2.10
2.40	3.10	4.40	2.80	2.40	2.00	1.80	1.60	1.70	1.70	1.70	2.00
2.20	3.10	4.40	2.80	2.50	2.00	1.70	1.60	1.70	1.60	1.70	2.70
2.40	2.90	4.00	2.80	2.50	2.00	1.80	1.60	1.60	1.60	1.70	2.70
2.40	2.80	3.70	3.50	2.40	2.00	1.90	1.60	1.60	1.60	1.90	2.70
2.40	5.99	4.55	3.85	2.35	2.00	2.50	1.50	1.60	1.60	1.80	2.40
2.30	10.40	5.50	3.30	2.35	2.15	2.70	1.60	1.60	1.60	1.70	2.10
2.30	.....	6.20	3.00	2.35	2.20	2.05	2.20	1.70	1.60	1.70	2.10
2.30	.....	5.30	2.90	2.30	2.10	2.00	2.10	1.70	1.60	1.70	2.10
2.20	.....	4.40	.....	2.30	.....	2.20	1.90	.....	1.80	.....	2.00

wba River in South Carolina is known as Wateree River. It with Congaree River to form the Santee. The United States er Bureau has maintained a station at Camden, South Caro- ı Wateree River, 43 miles above its mouth. The gage is a nber attached to the central granite pier of the South Carolina, orgia Extension Railroad bridge. The top of the rail on the is 47.0 feet above zero of gage. The highest water recorded 5 feet, in September, 1886; the lowest, 0.0 feet, in June, 1884. ınger line is at 24 feet. The drainage area at this point, ng to the Weather Bureau, is 2,635 square miles.

BROAD RIVER AT GAFFNEY, SOUTH CAROLINA.

d River rises on the eastern slope of the Blue Ridge Mountains, ickorynut Gap, in the west-central part of North Carolina, and in a general southeasterly direction unites with Saluda River Columbia, South Carolina, to form the Congaree. The drainage mprises about 4,950 square miles, of which 3,550 are in South a and 1,400 in North Carolina, and is partly mapped on the ıton, Mount Mitchell, and Saluda atlas sheets. The upper part basin is rough, broken country largely covered with forests. h Carolina the topography is flatter and for the greater part ıd is under cultivation. Broad River receives a number of ınt tributaries, but there are no towns of importance along it. are a number of sites for the possible development of water

power along its course, the most important of which are described in the Nineteenth Annual Report, Part IV, page 215. Systematic measurements of the flow have been made at Gaffney, South Carolina, 15 miles below the North Carolina line, and at Alston, 20 miles above Columbia, South Carolina. The station at Gaffney, described in the Eighteenth Annual Report, Part IV, page 65, was established by E. W. Myers July 1, 1896, and was located at the Southern Railway bridge, about 3 miles from Gaffney, South Carolina. This station was maintained until October 25, 1898, when the gage rod was moved to Gaffneys Ferry, 200 yards above the bridge, as described in Water-Supply Paper No. 27, page 27. The bench mark is described in the same paper. The velocity is quite rapid, well distributed all the way across, and the channel is straight for some distance above and below the station. The ferryman, John W. Gaffney, Gaffney, South Carolina, was employed to take charge of the gage. The results of discharge measurements are found as follows: 1896, Eighteenth Annual Report, Part IV, page 66; 1897, Nineteeth Annual Report, Part IV, page 220. The following measurements were made by E. W. Myers during 1899:

February 10, gage height, 3.70 feet; discharge, 4,702 second-feet.
February 22, gage height, 2.25 feet; discharge, 4,497 second-feet.
April 15, gage height, 3.20 feet; discharge, 3,510 second-feet.
June 12, gage height, 2.40 feet; discharge, 2,496 second-feet.
October 4, gage height, 1.70 feet; discharge, 692 second-feet.
October 4, gage height, 1.70 feet; discharge, 662 second-feet.
December 17, gage height, 1.65 feet; discharge, 1,485 second-feet.

Daily gage height, in feet, of Broad River at Gaffney, South Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	2.40	5.00	3.90	2.80	2.10	1.80	1.90	2.50	1.30	1.60	1.40
2	2.40	2.40	3.90	3.50	2.80	2.10	1.80	1.80	2.00	1.20	1.70	1.40
3	2.20	2.30	3.50	3.40	2.60	2.00	1.70	1.80	1.90	1.40	1.80	1.50
4	2.10	2.30	3.40	3.60	2.50	2.10	1.70	1.70	1.70	1.30	1.60	1.50
5	2.00	5.80	3.40	4.90	2.70	2.10	1.70	1.60	1.60	1.30	1.60	1.40
6	2.80	8.20	3.50	3.60	2.70	1.90	1.60	1.60	1.50	1.70	1.50	1.30
7	8.40	10.20	3.30	4.50	2.60	2.00	1.70	1.50	1.20	1.60	1.60	1.40
8	5.40	7.20	3.10	6.40	2.50	2.00	1.70	1.50	2.00	1.70	1.50	1.40
9	4.60	.....	3.00	4.50	2.50	2.00	1.80	1.50	2.20	1.80	1.40	1.30
10	3.00	.....	3.00	4.00	2.40	2.00	1.80	2.00	1.90	1.80	1.50	1.30
11	3.10	.....	2.90	3.70	2.40	2.00	1.70	2.50	2.00	1.70	1.50	1.40
12	3.00	3.70	2.90	3.50	2.40	2.00	1.60	2.10	1.60	1.70	1.40	2.00
13	3.00	3.50	2.90	3.40	4.50	3.20	1.60	1.90	1.30	1.60	1.35	3.50
14	3.00	3.40	3.50	3.20	3.70	2.30	1.60	1.80	1.30	1.40	1.40	2.20
15	3.20	3.10	9.20	3.20	2.80	2.20	1.60	1.90	1.20	1.40	1.60	1.90
16	3.10	3.90	10.00	3.30	2.70	2.10	1.50	1.70	1.20	1.50	1.40	1.80
17	2.90	6.80	8.30	3.20	2.40	2.00	1.50	1.60	1.20	1.50	1.50	1.70
18	2.80	4.30	5.80	3.10	2.40	2.20	1.60	1.50	1.30	1.60	1.40	1.80
19	2.60	3.70	12.20	3.00	2.40	1.80	1.60	1.40	1.30	1.50	1.30	1.60
20	2.50	3.40	11.50	3.00	2.20	1.80	1.90	1.40	1.40	1.40	1.30	1.70
21	2.30	3.10	5.60	2.90	2.50	1.80	1.80	1.30	1.70	1.40	1.30	1.60
22	2.20	3.10	5.60	2.90	2.20	1.70	1.70	1.40	1.60	1.30	1.40	1.50
23	2.30	3.00	4.80	2.90	2.20	1.70	1.70	1.40	1.40	1.30	1.50	1.60
24	2.20	2.80	4.50	2.60	2.20	1.60	1.60	1.50	1.20	1.40	1.50	2.80
25	2.40	2.80	4.20	3.30	2.20	2.00	1.60	1.50	1.40	1.30	1.50	2.40
26	2.20	2.80	4.00	4.10	2.10	1.70	1.90	1.50	1.60	1.30	1.60	2.30
27	2.20	9.80	4.50	3.20	2.10	2.20	2.60	2.60	1.50	1.20	1.60	2.00
28	2.10	7.00	4.60	3.10	1.90	2.10	1.90	1.90	1.30	1.30	1.60	1.70
29	2.20	.....	5.50	2.90	2.00	2.00	1.90	2.00	1.40	1.30	1.50	1.60
30	2.20	.....	4.00	2.80	2.20	1.80	1.80	1.90	1.70	1.40	1.50	1.60
31	2.30	.....	4.00	.....	2.10	.....	1.80	2.30	.....	1.50	.....	1.50

BROAD RIVER AT ALSTON, SOUTH CAROLINA.

station, described in the Eighteenth Annual Report, Part IV, 7, was established by E. W. Myers, July 3, 1896, and is located Southern Railway bridge near Alston, South Carolina, and 60 below the Gaffney station. The length of the wire gage is 42.65 The gage was verified December 19, 1899. The section here a good one, being broken by the foundations of an old bridge ıg at the same place as the present one. The bed is flat, muddy, omewhat shifting. The river is straight for a long distance and below the station. The current is swift and the velocity uniform across the section. The observer is D. R. Elkin, a r of Alston, South Carolina. Records of discharge may be as follows: 1896, Eighteenth Annual Report, Part IV, page 68; ınd 1898, Twentieth Annual Report, Part IV, page 151. The ing measurements were made by E. W. Myers in 1899:

uary 19, gage height, 10.15 feet; discharge, 28,930 second-feet.
14, gage height, 4.33 feet; discharge, 6,289 second-feet.
ber 2, gage height, 2.14 feet; discharge, 1,645 second-feet.
mber 19, gage height, 2.91 feet; discharge, 3,319 second-feet.

gage height, in feet, of Broad River at Alston, South Carolina, for 1899.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
..	3.42	4.78	11.50	8.83	4.30	3.32	2.77	3.10	4.50	2.20	4.47	2.90
..	3.88	4.60	8.00	6.74	4.10	3.30	2.74	3.00	4.45	2.12	3.10	3.16
..	3.90	4.30	6.54	5.51	4.09	3.20	2.50	2.55	3.55	1.97	2.87	3.14
..	3.43	4.30	7.42	5.30	4.00	3.10	2.76	3.08	3.65	2.20	3.88	2.80
..	3.35	6.90	7.42	6.10	3.99	3.10	2.53	2.50	3.00	2.34	2.74	2.66
..	3.47	13.00	10.51	6.10	3.99	2.80	2.63	3.00	2.90	6.28	2.62	2.82
..	9.50	18.00	6.20	5.61	4.11	2.90	2.60	2.80	2.78	3.52	2.37	2.70
..	14.00	18.50	5.53	8.33	4.20	2.89	2.62	2.10	3.45	4.18	2.64	2.65
..	9.40	12.90	5.11	9.00	3.98	2.90	2.73	2.80	3.43	3.22	2.58	2.71
..	7.10	9.50	4.90	7.14	3.82	2.88	2.90	2.65	3.52	2.90	2.51	2.66
..	5.78	6.78	4.79	6.13	3.63	2.89	2.60	2.75	9.30	2.86	2.50	2.53
..	7.20	5.80	4.71	5.88	3.69	3.40	2.48	4.50	4.40	2.68	2.56	6.48
..	7.35	5.40	4.42	5.40	3.70	3.10	2.43	3.34	3.60	2.58	2.78	8.13
..	6.71	4.86	4.59	5.20	3.88	4.28	2.30	2.80	2.81	2.60	2.23	5.13
..	7.51	4.54	6.28	5.03	4.68	3.70	2.34	2.55	2.62	2.58	2.50	4.42
..	6.10	8.33	14.40	4.90	3.98	3.35	2.33	2.55	2.60	2.43	2.60	3.70
..	6.20	15.30	15.39	4.87	3.62	3.00	2.24	2.55	2.40	2.21	2.57	3.34
..	5.32	12.69	10.50	4.65	3.52	3.40	2.09	2.23	2.30	2.52	2.58	3.07
..	4.70	10.10	8.00	4.69	3.40	3.10	2.28	2.20	2.35	2.54	2.51	2.91
..	4.33	6.84	15.30	4.68	3.45	2.92	2.10	2.00	2.60	2.49	2.43	3.22
..	4.11	6.23	13.94	4.54	3.30	2.84	2.83	2.15	2.63	2.57	2.29	3.08
..	4.00	6.52	8.94	4.41	3.40	2.82	2.52	2.14	2.60	2.42	2.52	2.90
..	3.82	5.61	7.00	4.30	3.43	2.79	2.30	2.40	2.50	2.20	4.71	3.60
..	4.10	5.11	7.12	4.40	3.88	2.73	2.17	2.30	2.39	2.15	3.61	7.32
..	4.20	4.61	6.40	4.13	3.72	2.51	2.40	3.40	2.30	2.45	3.10	8.20
..	4.55	4.62	5.90	6.61	3.32	2.60	2.95	2.35	2.08	2.40	5.54	4.44
..	4.00	13.72	5.80	6.64	3.30	2.70	6.25	3.55	2.60	2.39	4.25	3.00
..	3.80	17.98	7.30	5.30	3.30	3.78	4.72	5.55	2.35	2.41	3.50	3.76
..	3.90	.....	7.72	4.70	3.28	3.30	3.80	4.70	2.29	2.40	3.30	3.75
..	4.10	.....	7.43	4.40	3.11	2.93	2.09	4.28	2.47	2.30	3.04	.....
..	4.50	.....	6.84	.....	3.11	.....	3.15	4.50	.....	4.57	.....	.....

ıd River joins Saluda River at Columbia, South Carolina, to Congaree River. The United States Weather Bureau has ıined river-height observations at Columbia, South Carolina. ıge rod is painted on the first stone pier from the eastern shore

of the Gervais street toll bridge. The bench mark is the track of the South Carolina and Georgia Extension Railroad at the Union Station, and is at an elevation of 102.59 feet above the zero of the gage. The high-water mark is 34.4 feet, and was reached in September, 1852; the lowest, —0.4 foot, on January 20, 1893. The danger line is 15 feet. The drainage area above the station, according to the United States Weather Bureau, is 7,300 square miles.

Santee River is formed by the junction of Wateree and Congaree rivers. The United States Weather Bureau has maintained a gage on Lower Santee River at St. Stephen, South Carolina, 50 miles above its mouth. The gage rod is attached to the downstream side of the central granite pier of the railroad bridge. The top of the rail on this bridge is 31 feet above zero of gage. The high-water mark is 20.2 feet, and was reached on September 18, 1888; the lowest, 1.3 feet, on October 6, 1895. The danger line is at 12 feet. The area drained at this point, according to the United States Weather Bureau, is 13,600 square miles.

SALUDA RIVER AT WATERLOO, SOUTH CAROLINA.

Saluda River rises in the mountains between North and South Carolina, flows in a southeasterly direction, and unites, near Columbia, South Carolina, with the Broad, to form the Congaree. The drainage area is partly mapped on the Saluda, Pickens, Pisgah, and Abbeville atlas sheets. Measurements have been made on the Saluda to determine the available water power. The station was established by E. W. Myers, August 30, 1896, and is described in the Eighteenth Annual Report, Part IV, page 68. It is 1 mile below the mouth of Reedy River, at the Charleston and Western Carolina Railway bridge, about 3 miles from Coronaca Station, South Carolina. The length of the gage wire is 47.00 feet. The length of the gage was verified December 19, 1899. The river here is straight for several hundred yards above and below the bridge. The flow is probably influenced by dams some miles above. The bed of the stream is of sand and mud and liable to change during high water. The banks are low, the right bank being subject to overflow. The observer is R. N. Cunningham, storekeeper and farmer at Waterloo, South Carolina. The locality is reached by private conveyance from Greenwood, South Carolina. The discharge measurements are made from the railroad bridge. Records of results may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 68; 1897, Nineteenth Annual Report, Part IV, page 221; 1898, Twentieth Annual Report, Part IV, page 153. The following measurements were made by E. W. Myers during 1899:

February 20, gage height, 7.60 feet; discharge, 3,350 second-feet.
June 14, gage height, 5.30 feet; discharge, 1,740 second-feet.
October 1, gage height, 3.65 feet; discharge, 604 second-feet.
December 19, gage height, 4.00 feet; discharge, 995 second-feet.

ily gage height, in feet, of Saluda River at Waterloo, South Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.00	5.75	12.80	8.75	6.00	4.75	4.95	3.80	3.90	3.65	4.75	4.60
2	4.65	5.40	8.90	7.55	5.90	4.40	3.95	3.70	5.20	2.85	4.50	4.45
3	5.05	5.60	7.65	7.05	5.80	5.15	3.85	3.65	5.25	3.60	4.65	3.80
4	4.90	6.25	7.60	7.15	5.60	4.35	4.20	3.70	3.25	4.35	4.40	3.05
5	4.80	6.85	8.00	7.30	6.00	4.15	3.20	4.75	3.95	4.20	3.80	3.90
6	5.00	10.60	8.10	7.60	5.95	5.05	3.75	4.00	3.85	5.50	2.90	4.25
7	14.00	18.50	7.25	7.20	6.15	4.10	3.80	3.30	3.70	4.50	4.35	3.80
8	14.30	17.35	6.70	7.95	5.80	4.00	4.85	3.90	4.10	5.65	4.30	3.85
9	6.05	12.70	6.50	8.35	5.85	3.80	4.65	4.60	4.85	4.00	4.35	4.25
10	7.05	8.60	6.70	7.40	6.55	3.70	3.45	4.00	3.85	4.00	4.35	3.45
11	6.50	7.60	6.30	6.90	5.50	3.75	3.70	5.50	6.60	4.10	4.15	3.00
12	6.90	7.10	6.45	6.95	5.30	5.85	3.70	4.90	5.50	4.00	3.70	5.90
13	7.50	7.00	6.45	6.75	5.20	5.50	3.60	4.50	3.95	4.00	2.90	7.10
14	7.80	5.60	6.25	6.65	4.95	5.55	3.60	3.20	3.80	4.65	4.00	5.85
15	7.45	6.50	10.30	6.30	4.80	4.45	4.75	3.65	4.50	4.10	4.45	5.00
16	6.95	12.55	15.35	6.55	4.60	4.25	4.50	3.65	4.10	3.00	4.35	4.85
17	6.65	15.20	13.85	6.35	4.70	4.90	3.60	3.55	3.50	4.20	4.05	4.45
18	6.25	13.10	10.30	6.25	4.55	4.60	3.50	4.55	2.85	4.00	4.25	4.10
19	6.30	8.60	9.75	6.45	4.50	4.65	3.60	4.15	3.95	4.75	3.70	4.75
20	5.90	7.40	11.98	6.30	5.15	4.05	3.55	3.45	3.90	4.70	2.95	3.90
21	5.40	7.60	13.18	6.20	4.60	4.10	4.45	2.70	3.90	5.45	3.95	4.50
22	5.85	7.45	8.75	5.55	5.05	3.75	4.50	4.20	3.90	3.20	4.05	4.55
23	5.70	9.85	8.65	5.90	4.50	3.65	3.60	3.70	4.80	3.00	6.45	4.30
24	5.45	6.55	8.90	6.15	4.40	4.90	2.90	3.75	3.60	4.15	4.40	7.15
25	5.50	6.35	7.80	7.90	4.35	4.10	4.75	3.70	2.90	4.35	4.85	5.15
26	5.20	6.70	7.55	8.10	4.30	3.60	5.10	4.35	3.90	4.55	5.25	4.75
27	5.00	17.55	7.05	7.15	5.15	4.15	5.40	5.00	4.35	4.55	4.15	4.95
28	6.75	15.60	7.35	6.55	5.10	4.05	5.00	4.75	4.45	4.20	5.05	4.55
29	6.55	.....	7.95	6.00	3.75	4.20	5.45	4.35	3.80	3.83	5.00	4.15
30	4.10	.....	7.25	6.10	4.15	3.80	5.40	4.80	4.00	2.95	4.15	4.75
31	5.30	.....	9.35	.....	4.15	.....	3.80	4.40	.....	4.40	.....	4.40

TUGALOO RIVER AT MADISON, SOUTH CAROLINA.

This river is formed by the junction of the Tallulah and Chattooga vers, which have their sources in the Blue Ridge Mountains. The sin is largely covered with an original growth of oak, and is tremely wild and picturesque. The drainage area is mapped on e following atlas sheets: Nantahala, Dahlonega, Walhalla, and owee. There are many beautiful falls in this watershed, the most ted of which are Tallulah Falls, with a drop of 335 feet in four ccessive leaps, the total fall in 2⅔ miles being 525 feet; and Toccoa lls, on Toccoa Creek, with a vertical drop of about 190 feet. This tter stream should not be confused with Toccoa River, a tributary of iwassee River, and on which a gaging station is maintained at Blue idge, Georgia. The gaging station on Tugaloo River was established ly 19, 1898, at Cooks Ferry, about one-half a mile from Madison, uth Carolina, one mile below the Southern Railway bridge over igaloo River and 2 miles above the mouth of Chauga Creek. The ge is a 2 by 4 inch scantling 10 feet long, nailed to a sycamore tree the right bank at the ferry landing. The bench marks are on the 't bank of the river, the first being on a willow tree at the ferry nding, and consisting of three large nails 3.00 feet above zero of gage; e second is on the same tree, being one nail 6.00 feet above zero of ge; the third is a large nail in a sycamore tree at the ferry landing .00 feet above the zero of the gage. Discharge measurements are ide from a boat held in place by the ferry rope stretched across the

river. The results of the measurements are given in the Twe Annual Report, Part IV, page 162. The following measure were made by Max Hall and others in 1899:

April 21, gage height, 4.50 feet; discharge, 2,604 second-feet.
May 22, gage height, 3.20 feet; discharge, 1,687 second-feet.
June 20, gage height, 2.10 feet; discharge, 1,325 second-feet.
September 12, gage height, 1.00 foot; discharge, 734 second-feet.
October 4, gage height, 0.70 foot; discharge, 512 second-feet.

A number of discharge measurements were made on various t taries of Tugaloo River during the fall of 1899. A measurem Tallulah River above the falls at the wagon bridge at Tal Falls, Georgia, was made October 3, when the discharge was f to be 153 second-feet; a second measurement was made No ber 25, giving a discharge of 188 second-feet. Two discharge urements were made on Toccoa Creek, above the falls, 2½ miles Toccoa, Georgia, on October 4; they were made at different sec on the river, and gave 5.7 and 5.9 second-feet, respectively. Ch Creek enters the Tugaloo about 2 miles below the gaging statio measurement was made on this stream at the wagon bridge ne mouth at Madison, South Carolina, on October 4, when the disc was found to be 99 second-feet.

Daily gage height, in feet, of Tugaloo River at Madison, South Carolina, fo

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	4.10	3.90	6.60	6.40	4.30	2.50	1.70	1.40	3.10	0.70	0.90
2	3.40	3.40	5.90	5.90	4.20	2.40	1.60	1.40	2.70	.70	.80
3	3.30	3.50	5.80	5.70	4.10	2.40	1.60	1.30	3.30	.70	.80
4	3.20	7.60	5.40	5.90	4.00	2.30	1.50	1.20	1.90	.70	.80
5	3.20	6.80	6.90	6.00	4.30	2.50	1.50	1.10	1.70	.80	.80
6	6.45	11.85	6.00	5.60	4.10	3.30	1.60	1.10	1.40	.90	.70
7	5.80	12.70	5.50	7.80	4.80	2.20	1.90	1.10	1.30	.80	.70
8	4.60	8.80	5.20	8.70	4.00	2.20	1.60	1.00	1.20	3.30	.70
9	4.20	6.80	5.20	6.80	3.80	2.10	1.60	1.00	1.20	2.50	.70
10	3.90	5.80	4.90	6.20	3.70	2.00	1.60	1.40	1.10	1.50	.70
11	4.20	5.50	4.80	5.80	3.70	2.20	1.50	1.30	1.10	1.00	.70
12	4.10	5.30	4.70	5.50	3.60	3.90	1.40	1.00	1.00	.90	.70
13	3.90	8.40	4.20	5.30	3.60	5.30	1.30	.90	.90	.90	.70
14	4.00	4.40	8.05	5.20	3.40	3.50	1.30	1.00	.90	.80	.70
15	4.50	4.50	16.15	5.00	3.30	2.80	1.30	1.00	.80	.80	.70
16	4.00	5.60	13.80	5.10	3.20	2.40	1.20	1.00	.80	.80	.70
17	3.90	5.60	8.40	4.90	3.20	2.50	1.20	1.20	.80	.80	.70
18	3.70	5.00	6.90	4.80	3.10	2.40	1.20	1.00	.80	.90	.70
19	3.40	4.80	16.15	4.80	3.20	2.20	1.10	.90	.80	1.00	.70
20	3.40	4.60	11.60	4.60	3.00	2.10	1.20	.80	.90	1.00	.70
21	3.30	4.50	8.40	4.50	2.90	2.00	1.20	.80	.90	.90	.70
22	3.20	4.50	7.60	4.40	3.10	2.90	1.40	.80	.80	.90	.80
23	3.10	4.40	8.40	4.30	3.00	2.90	1.30	.90	.80	.90	.90
24	3.20	4.30	7.30	4.20	2.80	2.80	1.70	.80	.80	.80	1.10
25	3.40	4.10	6.80	6.80	2.70	2.00	1.40	.90	.80	.80	.90
26	3.20	6.50	6.40	6.00	2.70	1.80	4.10	.80	.90	.80	1.60
27	3.20	9.80	6.20	5.20	2.60	2.10	4.20	1.20	.90	.80	2.60
28	3.10	8.10	6.10	4.80	2.60	2.10	2.40	1.00	.80	.80	1.70
29	3.00	.....	6.80	4.60	2.60	2.00	2.90	.90	.80	.90	1.30
30	2.90	.....	6.00	4.40	2.50	1.80	1.90	1.40	.70	.90	1.10
31	3.10	.....	6.90	.....	2.50	.....	1.60	6.50	.....	.80	.....

SAVANNAH RIVER AT CALHOUN FALLS, SOUTH CAROLINA.

Savannah River is formed by the junction of Seneca and Tugaloo rivers about 100 miles above Augusta, Georgia. The headwater tributaries have their sources in the Blue Ridge Mountains in North and South Carolina and Georgia, where more than one-fifth of the territory is in original oak forest. The drainage area is partly mapped on the following atlas sheets; Pisgah, Cowee, Dahlonega, Walhalla, Pickens, Abbeville, Elberton, Nantahala, and Carnesville. A large number of fine water powers occur on the tributaries and along the main river, the most noted being at Tallulah Falls on Tallulah River, 835 feet in height, there being a total fall of 525 feet in a distance of 2¼ miles. In order to determine the value of these waterpowers, systematic measurements were begun at Calhoun Falls, South Carolina, on August 4, 1896. This station, described in the Eighteenth Annual Report, Part IV, page 73, is at the Seaboard Air Line bridge, across Savannah River, above the mouth of Beaverdam Creek and below Rocky River, and about 3 miles west of the town of Calhoun Falls, South Carolina. The river here is divided into two channels by a large island containing several hundred acres. The east channel is a good section at ordinary stages, but at lowest water the current is very sluggish. The west channel, which is the main river, is obstructed by some very small islands and old cofferdams about the two piers, otherwise the section is a good one. The bed is rocky and constant. The wire gage is on the west channel, center span; its length is 65.40 feet. One bench mark on the top of the iron stringer under the cross-ties near the gage is 54.00 feet above the datum of the gage; the other is on the top of the first pier on east side of west channel, and is 30.85 feet above zero of gage. Zero of gage is 354.5 above sea level. The gage was verified on March 4, 1899. The observer is Peter J. Pfeiffer, a farmer at Calhoun Falls, South Carolina. Records of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 75; 1897, Nineteenth Annual Report, Part IV, page 224; 1898, Twentieth Annual Report, Part IV, page 164. The following measurements were made by B. M. Hall and Max Hall during 1899:

March 4, gage height, 4.77 feet; discharge, 12,076 second-feet.
May 16, gage height, 3.45 feet; discharge, 5,258 second-feet.
September 28, gage height, 2.30 feet; discharge, 2,057 second-feet.
November 10, gage height, 2.25 feet; discharge, 2,039 second-feet.

Daily gage height, in feet, of Savannah River at Calhoun Falls, South Carolina, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	6.60	4.00	3.30	3.20	3.30	3.00	2.20	2.60	2.70
2	.....	5.00	3.90	3.20	3.00	3.10	2.90	2.10	2.50	2.80
3	.....	4.85	3.80	3.20	2.90	3.00	2.90	2.10	2.50	2.90
4	4.75	4.90	3.80	3.20	2.70	2.90	2.80	2.20	2.40	2.70
5	4.95	4.75	3.70	3.10	2.70	2.80	2.70	2.40	2.40	2.60
6	4.65	4.70	3.90	3.00	2.60	2.70	2.90	3.00	2.40	2.60
7	4.40	4.75	3.90	2.90	2.70	2.60	2.90	2.80	2.50	2.60
8	4.35	4.65	3.80	3.00	2.70	2.60	3.00	3.90	2.40	2.50
9	4.25	5.60	3.80	3.30	3.00	3.00	3.00	3.50	2.30	2.50
10	4.20	5.10	3.70	3.20	2.90	2.90	2.90	3.20	2.20	2.40
11	4.05	4.95	3.70	3.40	2.80	2.80	3.20	3.00	2.20	2.50
12	3.90	4.80	3.70	3.50	2.80	2.80	3.00	2.70	2.10	4.90
13	4.00	4.70	3.60	5.00	2.70	2.70	3.00	2.50	2.10	5.00
14	4.00	4.50	3.60	3.90	2.60	2.70	2.90	2.40	2.00	3.80
15	5.25	4.30	3.50	3.70	2.50	2.60	2.90	2.30	2.10	3.50
16	13.60	4.00	3.40	3.60	2.40	2.60	2.80	2.40	2.10	3.30
17	9.00	3.90	3.40	3.60	2.40	2.60	2.70	2.40	2.10	3.10
18	6.90	3.70	3.40	3.50	2.30	2.60	2.60	2.30	2.00	3.00
19	7.00	3.70	3.50	3.30	2.40	2.50	2.60	2.30	2.00	3.00
20	9.00	3.50	3.50	3.20	2.30	2.50	2.90	2.40	2.00	2.90
21	7.05	3.40	3.40	3.10	2.20	2.60	2.90	2.30	2.10	2.90
22	5.00	3.20	3.50	3.00	2.30	2.80	2.80	2.30	2.10	2.80
23	5.00	3.00	3.70	3.00	2.30	3.00	2.60	2.30	2.30	2.70
24	4.90	2.90	3.55	2.90	2.30	2.90	2.50	2.20	2.30	3.90
25	5.00	4.00	3.50	2.90	2.40	2.70	2.40	2.20	2.40	3.80
26	5.10	4.60	3.40	3.00	2.70	2.70	2.60	2.20	4.00	3.50
27	4.95	5.10	3.25	3.90	2.70	2.80	2.40	2.10	3.40	3.50
28	4.85	5.00	3.20	4.00	5.00	3.00	2.30	2.10	3.20	3.60
29	6.95	4.70	3.20	3.60	3.50	2.90	2.30	2.20	2.90	3.70
30	5.10	4.10	3.10	3.30	3.60	3.50	2.20	2.30	2.80	3.60
31	7.00	.....	3.30	.....	3.40	3.20	.....	2.50	.....	2.90

SAVANNAH RIVER AT AUGUSTA, GEORGIA.

Observations of river height have been maintained since 1875 by the city of Augusta, at the city highway bridge. The results have been printed in a volume entitled "Stages of water at river stations," prepared by the United States Weather Bureau. Those for 1875 to 1889 are given in Part III, those for 1890 to 1892 in Part IV, and for 1893 to 1895 in Part V of the above-mentioned publication. The gage consists of a vertical timber fastened to the pier and graduated to feet and inches. Readings are made four times a day by J. M. Youngblood, keeper of the city bridge, usually at 6 a. m., 12 m., 6 p. m., and 9 p. m. The 6. a. m. readings are those used by the Weather Bureau, and are here given, excepting September, October, and November, when the average of all four readings is given, since at that season nearly all of the water passes through the factory wheels above the gage. The channel is straight and without obstructions; the banks are moderately high, but are liable to overflow at the highest floods. Bed is fairly constant. Records of measurement may be found as follows: 1875 to 1891, Fourteenth Annual Report, Part II, page 147; 1891 to 1896, Eighteenth Annual Report, Part IV, page 75; 1897, Nineteenth Annual Report, Part IV, page 227; 1898, Twentieth Annual Report, Part IV, page 165. The following measurements have been made by B. M. Hall and his assistants during 1899:

Measurements of Savannah River at Augusta, Georgia.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
March 17	25.20	60,716	May 29	7.60	6,271
March 18	20.60	35,971	July 1	7.22	5,391
May 8	9.70	10,860	August 3	6.68	4,226
May 9	9.50	9,908	October 10	12.48	14,618

Daily gage height, in feet, of Savannah River at Augusta, Georgia, for 1899. (a)

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.5	12.7	28.8	19.5	9.6	7.9	7.2	7.4	13.9	5.0	6.2	7.3
2	10.8	13.0	21.0	18.9	9.5	8.4	6.7	6.7	10.9	5.0	6.4	6.9
3	10.3	14.3	16.2	15.3	9.3	7.6	6.2	6.3	9.1	5.5	6.3	5.8
4	9.0	15.8	14.2	13.2	9.3	7.5	6.0	6.3	8.0	5.6	5.8	7.0
5	8.5	14.5	13.7	12.9	9.2	7.2	6.0	6.0	7.5	5.8	5.6	8.7
6	8.5	20.7	16.2	13.0	9.8	7.3	6.0	5.9	6.9	11.8	5.8	6.7
7	12.8	28.0	15.2	12.2	10.3	7.3	5.8	5.7	6.6	9.6	5.9	6.3
8	22.9	31.0	13.3	12.4	10.4	7.0	6.7	5.5	7.4	10.5	5.8	6.3
9	19.2	29.9	12.2	15.5	9.7	7.0	7.0	5.7	7.0	14.1	5.9	6.1
10	14.3	22.9	11.8	14.2	9.1	6.9	8.3	6.0	7.0	12.1	5.8	6.0
11	12.8	18.3	11.5	12.8	8.8	7.3	7.8	5.7	8.7	8.5	5.5	5.9
12	17.3	14.7	11.2	12.0	8.5	6.9	6.5	8.0	9.3	7.3	5.6	5.9
13	17.4	13.7	11.2	11.5	8.5	7.5	6.0	8.3	8.6	6.9	5.6	6.3
14	15.3	12.9	11.1	11.2	8.5	9.7	6.0	6.4	6.9	6.4	5.7	10.7
15	15.4	12.3	11.0	11.0	8.3	9.7	6.0	6.0	6.3	6.0	6.1	14.5
16	14.5	14.4	18.5	10.8	8.2	8.2	6.0	5.5	5.8	6.3	5.8	10.5
17	17.3	25.0	25.5	10.5	8.2	8.0	5.7	5.4	5.6	6.0	5.8	8.5
18	16.8	24.3	21.5	10.5	8.0	8.7	5.6	5.0	5.2	6.0	5.8	7.5
19	13.9	19.1	17.1	10.2	8.0	7.9	5.8	5.0	5.4	6.3	5.4	7.3
20	11.7	15.3	20.0	10.5	7.9	7.3	5.7	5.8	5.7	6.1	5.7	7.0
21	10.7	13.5	22.5	10.4	7.9	7.3	5.5	4.0	6.0	6.5	5.7	6.8
22	10.0	14.7	17.1	10.0	7.8	7.0	5.3	4.7	6.6	6.7	5.8	6.9
23	9.9	14.3	15.8	9.9	7.7	6.7	5.8	5.3	6.0	6.0	5.8	7.4
24	11.4	13.0	15.5	9.6	8.2	6.7	5.8	4.8	5.4	6.0	7.0	9.3
25	11.9	11.7	15.5	10.0	8.0	6.5	5.7	5.7	5.9	5.8	8.3	13.8
26	10.8	11.5	13.8	11.5	7.8	6.3	6.0	5.6	5.6	5.8	9.2	12.3
27	10.3	17.7	14.0	13.0	7.6	6.7	7.0	7.0	5.3	5.6	11.3	9.8
28	10.0	29.6	13.5	11.2	7.4	7.5	11.7	13.3	5.8	5.7	9.8	8.3
29	11.0	.....	14.0	10.3	7.4	7.7	11.6	11.3	5.8	5.6	8.4	5.0
30	11.2	.....	15.0	10.0	7.4	7.5	9.3	9.2	5.6	5.8	7.5	8.3
31	10.5	.....	13.5	.....	7.3	.....	8.5	11.4	.....	5.9	.....	7.7

a For the months of September, October, and November the figures given are an average of four readings daily—6 a. m., 12 m., 6 p. m., and 8 p. m. For the other months the readings are those taken at 6 a. m.

BROAD RIVER AT CARLTON, GEORGIA.

Broad River rises in the northeastern part of Georgia and flows in a southeasterly direction, passing between Elbert and Wilkes counties and emptying into Savannah River 8 miles below Calhoun Falls station. The watershed is a rolling country largely covered with timber. Measurements were begun on Broad River at Carlton on May 27, 1897, this station being established by Max Hall. It is located on the bridge of the Seaboard Air Line, 3 miles east of Carlton, Georgia, and 3 miles above the mouth of the South Fork. The iron bridge is 250 feet long and is approached on each side by wooden trestles. The initial point of soundings is the end of the iron bridge at right bank, upstream. The length of the wire gage is 56.30 feet. Bench mark is top of upstream iron girder under cross-tie at 30 feet from initial point and is 51.00 feet above datum. Zero of gage is 384.5 feet above sea level. The gage was last verified April 25, 1899. The

channel is straight and the flow uninterrupted except by one pier in the center of the river. The banks are rather low and subject to overflow in time of high water. The bed is fairly constant. The observer is S. P. Power, jr., a farmer at Carlton, Georgia. The results of measurements may be found as follows: 1897, Nineteenth Annual Report, Part IV, page 227; 1898, Twentieth Annual Report, Part IV, page 163. The following discharge measurements were made during the year 1899 by Max Hall and assistants:

Measurements of Broad River at Carlton, Georgia.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
February 28	9.05	8,281	June 28	2.80	1,063
March 1	5.28	3,205	September 27	2.00	514
April 25	3.65	1,841	November 11	2.05	485
May 15	2.60	919	December 21	2.25	591

A measurement of Broad River was made June 28 below the junction of South Broad, 3 miles below the station and 4 miles from Carlton, Georgia, which gave a discharge of 1,135 second-feet. On the same date a measurement of South Broad was made at its mouth, when the discharge was found to be 145 second-feet. On September 22 a second measurement of South Broad was made 4 miles above the mouth above Fork Creek and 1.5 of a mile from Carlton, Georgia, and gave 103 second-feet. On November 11 a third measurement of this latter river was made one-half a mile from mouth, below Fork Creek, and 3 miles from Carlton, giving a discharge of 139 second-feet. The drainage area of South Broad River at its mouth is 215 square miles.

Daily gage height, in feet, of Broad River at Carlton, Georgia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.10	3.45	5.20	5.80	3.00	2.60	2.30	2.40	3.80	1.90	2.15	2.35
2	2.95	3.00	4.10	4.45	3.00	2.55	2.25	2.35	3.00	1.90	2.10	2.40
3	2.75	3.75	3.80	3.60	2.95	2.50	2.20	2.25	2.50	1.90	2.10	2.30
4	2.70	3.70	3.60	3.65	2.95	2.50	2.20	2.20	2.30	1.90	2.05	2.30
5	2.65	4.30	3.95	3.70	3.00	2.45	2.20	2.20	2.20	2.00	2.05	2.25
6	4.45	7.20	4.20	3.45	3.20	2.40	2.20	2.15	2.15	2.20	2.05	2.20
7	6.45	13.18	3.65	3.60	3.15	2.40	2.25	2.10	2.10	2.15	2.05	2.20
8	6.40	10.60	3.45	4.40	3.00	2.50	2.40	2.10	2.10	4.30	2.05	2.20
9	3.90	5.45	3.40	4.20	2.95	2.60	2.30	2.10	2.10	3.40	2.05	2.20
10	3.30	4.30	3.35	3.60	2.95	2.45	2.40	2.10	2.10	2.50	2.05	2.20
11	3.80	3.75	3.30	3.50	2.90	2.40	2.30	2.15	2.50	2.35	2.05	2.20
12	4.05	3.60	3.30	3.40	2.85	2.60	2.25	2.10	2.10	2.25	2.05	3.40
13	3.70	3.45	3.25	3.30	2.80	3.70	2.20	2.15	2.50	2.20	2.05	3.60
14	3.45	3.35	3.50	3.30	2.80	3.00	2.20	2.05	2.00	2.15	2.05	2.95
15	3.75	3.30	4.40	3.25	2.75	2.40	2.15	2.00	2.00	2.10	2.10	2.50
16	3.50	4.40	13.88	3.25	2.75	2.50	2.10	1.95	1.95	2.10	2.10	2.45
17	3.50	5.05	11.30	3.20	2.70	2.65	2.10	1.90	1.95	2.10	2.05	2.35
18	3.65	4.45	4.70	3.15	2.70	2.65	2.25	1.90	1.95	2.10	2.05	2.30
19	3.10	3.80	4.50	3.25	2.65	2.55	2.15	1.90	1.95	2.10	2.05	2.30
20	3.00	3.50	8.10	3.20	2.65	2.45	2.10	1.90	2.05	2.10	2.05	2.30
21	2.90	3.55	5.20	3.15	2.60	2.40	2.10	2.00	2.00	2.10	2.05	2.25
22	2.85	3.60	4.00	3.10	2.65	2.35	2.05	1.95	2.00	2.05	2.05	2.25
23	2.95	3.50	4.15	3.05	2.70	2.30	2.20	2.00	2.00	2.05	3.65	2.20
24	3.05	3.30	4.55	3.10	2.65	2.30	2.25	1.95	1.95	2.05	3.45	4.40
25	3.00	3.20	3.75	3.20	2.60	2.30	2.15	2.00	1.95	2.05	2.45	4.30
26	2.95	3.15	3.60	3.50	2.60	3.70	2.45	2.05	1.95	2.05	3.60	3.00
27	2.85	15.78	3.50	3.20	2.60	3.00	6.50	3.95	2.00	2.05	3.70	2.60
28	2.80	11.15	3.45	3.15	2.55	2.80	5.30	2.45	1.95	2.05	2.90	2.60
29	2.80	.....	4.20	3.10	2.55	2.80	3.50	2.10	1.95	2.05	2.55	2.60
30	2.75	.....	3.70	3.10	2.50	2.50	2.80	3.50	1.90	2.10	2.40	2.50
31	3.10	.....	5.00	.....	2.70	.....	2.50	4.10	.....	2.15	.....	2.45

OCONEE RIVER AT DUBLIN, GEORGIA.

Oconee River rises in the northern part of Georgia, near Gainesville, on the southern slope of Chattahoochee Ridge, which separates the headwaters of this stream from the tributaries of Chattahoochee River. It flows in a southeasterly direction and joins the Ocmulgee at the southern border of Montgomery County to form the Altamaha. The watershed is for the most part hilly, and is made up of cultivated ground broken by extensive tracts of forest. A station was maintained for a time at Cary, Georgia, immediately below the mouth of Apalachee River. The rating was evidently affected by the dam several miles below, and for this reason the station was abandoned on March 31, 1898. The results of measurements at this station can be found as follows: 1897, Nineteenth Annual Report, Part IV, page 227; 1898, Twentieth Annual Report, Part IV, page 170. A single discharge measurement was made at this station in 1899 on October 19: Gage height, 2.03 feet; discharge, 898 second-feet.

A station was established by the United States Weather Bureau in 1894, at Dublin, Georgia, about 60 miles above the junction of the Oconee with the Ocmulgee, 45 miles below Milledgeville, and 85 miles below the old Cary station. The station was discontinued on April 30, 1897, but was reestablished by the Georgia geological survey, February 11, 1898. Since October 15, 1898, the station has been maintained by the United States Weather Bureau. The station is located about one-half mile east of Dublin, Georgia. The gage is a vertical rod fastened to the lower side of the middle pier of the Wrightsville and Tennille Railroad bridge. The gage is referred to a secondary gage on a hemlock tree on the right bank, 150 feet above, and to a bench mark on the same tree which consists of three large nails 3.00 feet above the zero of the gage, and a second bench mark on another hemlock tree 100 feet above the first, which consists of three large nails 3.00 feet above datum. The channel is straight and without obstructions except the bridge piers. The current is swift, the banks high and not subject to overflows. Discharge measurements are made from the upper side of the county highway iron bridge, which is about 100 yards above the railroad bridge at which the gage is located. The initial point for soundings is the end of the bridge on right bank of the river. Records of measurement may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 77; 1897, Nineteenth Annual Report, Part IV, page 228; 1898, Twentieth Annual Report, Part IV, page 170. The following measurements were made by B. M. Hall and his assistants during 1899:

February 2, gage height, 8.20 feet; discharge, 9,689 second-feet.
April 28, gage height, 8.00 feet; discharge, 9,033 second-feet.
June 8, gage height, 0.80 foot; discharge, 1,937 second-feet.
September 15, gage height, 0.80 foot; discharge, 1,997 second-feet.
September 15, gage height, 0.50 foot; discharge, 1,903 second-feet.
December 14, gage height, 3.90 feet; discharge, 4,028 second-feet.

A discharge measurement was also made on Oconee River at Milledgeville, Georgia, 45 miles above Dublin, on November 21, 1899, when the discharge was found to be 957 second-feet.

Daily gage height, in feet, of Oconee River at Dublin, Georgia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.80	7.70	11.30	8.30	5.40	1.70	0.50	2.90	2.50	-1.20	-0.40	2.40
2	3.60	8.10	13.80	8.00	4.70	1.80	.60	2.30	2.90	-1.30	-.40	1.10
3	5.20	9.10	16.50	8.50	3.80	1.70	.40	2.00	2.70	-1.30	-.40	2.00
4	5.80	9.90	17.00	9.00	3.70	1.50	.20	1.70	2.10	-1.30	-.50	1.90
5	5.00	10.70	16.90	9.80	3.50	1.40	.10	1.50	1.50	-.80	-.50	1.70
6	4.70	12.70	16.20	9.50	4.10	1.20	.00	.90	1.10	.50	-.50	1.60
7	5.00	13.10	14.50	9.00	5.00	1.00	.20	.80	.80	2.40	-.50	1.30
8	7.80	15.00	12.70	8.60	4.80	.80	.40	.70	.30	5.10	-.60	1.10
9	8.60	20.10	11.00	8.00	4.40	.70	.00	.20	.20	7.20	-.60	.90
10	10.40	22.50	9.80	7.80	3.60	.60	-.10	-.30	.10	8.10	-.70	.70
11	12.20	21.70	8.60	7.50	3.00	.50	-.10	-.40	.00	8.60	-.70	.50
12	14.10	18.90	7.60	7.00	2.70	.40	-.20	-.20	.10	6.80	-.70	1.20
13	14.40	17.50	7.00	6.40	2.70	.30	-.30	-.10	.70	4.10	-.80	2.60
14	15.30	16.80	6.80	5.60	2.40	.30	-.40	-.10	1.50	1.70	-.80	3.30
15	14.80	15.50	6.70	5.20	2.30	.90	-.40	-.20	.80	1.10	-.10	4.10
16	14.50	13.70	7.30	5.00	2.10	1.20	-.40	-.30	.10	.60	.70	3.20
17	14.30	12.40	7.90	4.90	2.00	.70	-.50	-.50	-.30	.50	.10	2.50
18	13.70	12.50	8.30	4.80	1.90	.30	-.60	-.60	-.40	.50	.80	1.90
19	13.30	12.70	9.20	5.30	1.80	.30	-.60	-.70	-.50	.50	.10	1.50
20	13.10	13.30	10.10	5.80	1.70	.60	-.60	-.80	-.60	.40	-.20	1.30
21	12.80	13.60	10.90	5.60	1.60	.90	-.70	-.80	-.70	.40	-.30	1.20
22	12.60	13.00	12.60	5.50	1.50	.50	-.70	-.90	-.80	.20	-.40	1.20
23	11.30	12.00	14.20	5.20	1.50	.30	-.70	-.70	-.90	.00	-.30	1.40
24	8.30	10.80	13.40	5.00	1.80	.20	-.80	-.30	-.90	-.10	.10	1.40
25	7.80	9.80	11.90	4.80	2.10	.20	-.80	-.20	-1.00	-.30	1.50	2.30
26	7.30	9.00	10.00	5.90	1.80	.00	.30	2.50	-1.00	-.40	1.30	5.30
27	7.10	9.70	9.60	7.40	1.70	-.10	.70	3.00	-1.10	-.50	2.10	5.60
28	6.80	9.60	8.90	8.00	1.60	-.20	.90	3.00	-1.10	-.60	3.20	4.00
29	7.00	.....	8.30	7.20	1.60	-.20	1.80	5.10	-1.10	-.70	4.40	3.90
30	7.40	.....	8.10	6.10	1.60	.40	4.70	4.50	-1.20	-.70	3.30	2.80
31	7.60	.....	8.00	.....	1.60	.....	5.00	2.90	.....	-.30	.....	2.60

YELLOW RIVER AT ALMON, GEORGIA.

This river is an important tributary of the Ocmulgee. Its headwaters are in Gwinnett County, only a short distance from Chattahoochee River. About one-third of the watershed is under cultivation, the ground being well terraced on the hillsides. The drainage area is entirely mapped on the Monroe, Gainesville, Suwanee, and Atlanta atlas sheets of the United States Geological Survey. There are a number of falls along the river capable of development for water power. A gaging station was established at Almon, 3 miles west of Covington, Georgia, September 12, 1897. It was at the low wagon bridge crossing the stream, 600 feet below the Georgia Railroad bridge. Results of measurements at this station may be found as follows: 1897, Nineteenth Annual Report, Part IV, page 230; 1898, Twentieth Annual Report, Part IV, page 170. No current-meter measurements were made during 1898, nor were the gage heights recorded. An attempt was made, however, to ascertain the fluctuations of discharge for comparison with the observations made at Macon. A rating table published on page 229 of the Nineteenth Annual Report, Part IV, was constructed from discharge measurements made during the autumn of 1897. A rating table for 1898 is published in Water-Supply Paper No. 27, of the United States Geo-

gical Survey. The application of such a table involves the assumption that the fluctuations at Almon are coincident with those at Macon, and as it is of uncertain accuracy, the old station at Almon has been abandoned and a new station was established May 9, 1899, by B. M. Hall, about 1 mile above the old station. It is intended to maintain this station for six months or more, in order to study the water powers above and below. The gage rod is fastened to a small tree on the left bank below the bridge, and referred to a bench mark on top of the downstream end of floor beam, 90 feet from the initial point of soundings, which is the right-bank end of the hand rail on the downstream side of the bridge. The elevation of bench mark is 20.81 feet above datum. The gage was verified May 9, 1899. The channel is straight, the current swift and not influenced by obstructions except at very low water, when the current is entirely under the west half of the bridge. The banks are high but are overflowed at the highest waters. The bed is rocky and constant. The following measurements were made by B. M. Hall and assistants during 1899:

May 3, gage height 2.97 feet; discharge 481 second-feet.
May 9, gage height 3.16 feet; discharge 561 second-feet.
May 16, gage height 2.30 feet; discharge 364 second-feet.
June 6, gage height 1.80 feet; discharge 235 second-feet.
June 27, gage height 2.42 feet; discharge 427 second-feet.
August 7, gage height 1.40 feet; discharge 218 second-feet.
October 19, gage height 1.70 feet; discharge 200 second-feet.

Daily gage height, in feet, of Yellow River at Almon, Georgia, for 1899.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.40	1.60	1.90	2.10	1.20	1.60	2.00
2	.....	2.10	1.50	1.80	2.00	1.20	1.60	2.70
3	.....	2.00	1.40	1.70	1.80	1.20	1.50	2.50
4	.....	1.90	1.30	1.60	1.60	1.20	1.50	2.30
5	.....	1.80	1.40	1.60	1.50	1.70	1.50	2.00
6	.....	1.80	1.50	1.40	1.50	2.00	1.50	1.90
7	.....	1.70	1.80	1.40	1.50	2.50	1.50	1.90
8	.....	1.70	1.60	1.40	1.50	4.00	1.50	1.90
9	3.20	1.70	1.80	1.30	1.40	2.80	1.50	1.90
10	2.80	1.70	1.60	1.30	1.40	2.20	1.50	1.90
11	2.80	1.70	1.40	1.30	2.50	1.80	1.50	1.90
12	2.70	2.00	1.40	1.30	2.00	1.80	1.50	4.00
13	2.70	2.50	1.30	1.20	1.70	1.80	1.50	3.00
14	2.50	2.10	1.30	1.20	1.50	1.80	1.50	2.50
15	2.50	1.90	1.20	1.20	1.50	1.70	1.50	2.30
16	2.50	1.80	1.20	1.10	1.40	1.70	1.60	2.00
17	2.30	1.80	1.20	1.10	1.40	1.70	1.50	2.00
18	2.10	1.80	1.80	1.00	1.40	1.70	1.50	2.00
19	2.30	1.70	1.40	1.00	1.30	1.70	1.50	2.00
20	2.10	1.60	1.40	1.00	1.30	2.00	1.50	2.00
21	2.00	1.50	1.60	1.00	1.30	1.90	1.50	2.00
22	2.30	1.50	1.80	1.00	1.30	1.70	1.50	2.00
23	2.80	1.50	2.00	1.00	1.30	1.50	2.20	2.00
24	2.50	1.40	1.40	1.00	1.20	1.50	2.20	5.50
25	2.20	1.40	1.60	1.00	1.20	1.50	1.90	4.60
26	2.00	3.20	2.40	3.60	1.20	1.50	4.50	3.40
27	2.00	2.60	5.80	3.00	1.20	1.50	4.00	2.50
28	2.00	2.00	5.00	2.80	1.20	1.50	3.20	2.50
29	1.90	2.00	3.70	2.70	1.20	1.60	2.50	2.50
30	1.80	1.80	2.80	2.50	1.20	1.70	2.00	2.50
31	3.30	.....	2.00	2.30	.....	1.70	.....	2.80

TOWALIGA RIVER AT JULIETTE, GEORGIA.

The drainage basin of this stream occupies a small area in central Georgia, its headwater tributary adjoining those of Flint River on the west, and small creeks draining into the Ocmulgee on the east. The river is a tributary of Ocmulgee River, entering it 25 miles above Macon. The area drained is a rolling country and extensively cultivated. A gaging station was established by B. M. Hall near its mouth, at the Southern Railway bridge, 2½ miles north of Juliette, Georgia, on May 5, 1899, but observations of gage heights were not started until November 2. The rod is 1 by 4 inches and 7 feet long, nailed to the timber crib at base of left bank pier of the iron single-span bridge. Bench mark No. 1 is at top of downstream iron girder under cross-ties at 40 feet from left end of bridge, and is 37.00 feet above gage datum. Bench mark No. 2, top of rail at same point, gage height 38.80 feet. At low stages measurements are made at the wagon bridge a half mile above the railroad bridge. Thomas Pittman, a farmer living one-half mile from the bridge, is the observer. His address is Berner, Georgia. The following measurements were made by B. M. Hall and assistants in 1899:

May 5, gage height 3.15 feet; discharge 581 second-feet.
May 17, gage height 1.80 feet; discharge 255 second-feet.
November 2, gage height 1.20 feet; discharge 167 second-feet.
November 2, gage height 1.20 feet; discharge 163 second-feet.
December 16, gage height 1.90 feet; discharge 184 second-feet.

Daily gage height, in feet, of Towaliga River at Juliette, Georgia, for 1899.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1	.....	1.70	9	1.20	1.60	17	1.60	1.80	25	1.20	3.80
2	1.20	1.65	10	1.10	1.55	18	1.30	1.70	26	3.35	2.50
3	1.20	1.65	11	1.20	1.50	19	1.30	1.70	27	3.20	2.10
4	1.10	1.75	12	1.10	3.70	20	1.20	1.70	28	2.20	1.10
5	1.10	1.75	13	1.10	3.60	21	1.30	1.70	29	1.95	2.00
6	1.10	1.65	14	1.10	2.50	22	1.20	1.50	30	1.80	1.90
7	1.10	1.55	15	1.10	2.00	23	1.30	1.60	31	.....	1.90
8	1.10	1.50	16	1.70	1.90	24	1.20	4.00			

OCMULGEE RIVER AT MACON, GEORGIA.

The Ocmulgee River rises in the north-central part of Georgia and flows in a southeasterly direction, joining the Oconee south of Mount Vernon to form the Altamaha River, which empties into the Atlantic Ocean. The drainage area has the same general features as that of the Oconee. A station was established by the United States Weather Bureau January 21, 1893, and measurements were begun by the United States Geological Survey in 1895. This station is described in the Eighteenth Annual Report, Part IV, page 79. The wire gage on the Macon, Dublin and Savannah Railroad bridge having been twice stolen in the spring of 1897, the observations were taken on the *Weather Bureau* gage referred to the same data, which is a vertical

rod bolted to the stone pier of the Central Railroad bridge. Bench mark, top of track on Central Railroad bridge, is 54.85 feet above zero of gage. Measurements of discharge are made from the wagon bridge, a short distance above. The channel is straight and without obstructions except two bridge piers. The current is over 1 foot per second at low water; the banks high and not subject to overflow. The bed of the river is soft and changeable. W. T. Bass, a clerk in a store near the gage, was observer for the United States Geological Survey and the Georgia geological survey until June 1, 1899, when the station was resumed by the United States Weather Bureau, in charge of Mr. T. S. Collins, observer. Records of measurement may be found as follows: 1893–96, Eighteenth Annual Report, Part IV, page 82; 1897, Nineteenth Annual Report, Part IV, page 232; 1898, Twentieth Annual Report, Part IV, page 171. The following measurements were made by B. M. Hall and his assistants during 1899:

Measurements of Ocmulgee River at Macon, Georgia.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
February 1	9.72	6,302	June 21	1.22	1,009
February 3	13.75	14,954	August 2	1.98	1,345
February 3	13.75	14,781	September 14	1.70	1,314
February 3	12.81	12,687	September 16	.80	793
April 14	4.50	2,587	October 21	2.30	1,814
April 29	5.00	3,094	December 13	4.50	3,000
June 7	1.60	1,015	December 15	2.50	1,540
June 9	1.48	983			

Daily gage height, in feet, of Ocmulgee River at Macon, Georgia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.42	9.00	14.72	11.30	4.05	4.40	1.50	2.50	2.00	0.30	0.80	1.70
2	6.60	8.41	11.14	8.71	3.80	2.80	1.50	2.10	1.80	.30	.00	1.50
3	5.96	13.70	9.11	7.97	3.60	2.60	1.20	1.40	2.00	.30	.00	1.20
4	5.21	11.98	8.32	7.86	3.50	2.60	.90	1.40	1.80	.40	.50	2.10
5	3.70	9.94	8.11	8.11	3.45	1.90	.90	1.20	1.80	.50	.50	1.90
6	4.12	10.80	7.62	7.85	8.10	1.80	1.00	1.00	1.10	2.30	.50	1.50
7	15.20	15.83	6.81	6.89	6.72	1.60	1.10	.80	.70	2.00	.40	1.30
8	12.65	13.42	6.72	6.50	5.30	1.60	1.50	.70	.70	10.00	.40	1.10
9	10.21	12.13	6.40	5.97	3.80	1.60	2.00	.60	.50	6.40	.40	1.10
10	9.23	10.80	6.11	5.63	3.55	1.40	1.30	.50	.40	3.20	.40	1.00
11	12.14	9.78	5.81	5.42	3.28	1.60	1.10	2.10	2.20	2.20	.40	1.10
12	11.87	8.21	5.74	5.01	3.10	1.50	.90	1.00	2.50	1.80	.50	3.70
13	9.38	7.60	5.69	4.71	2.96	2.30	.80	1.20	2.20	1.30	.50	4.70
14	8.96	7.13	5.58	4.58	2.90	2.90	.80	.80	1.70	1.00	.50	3.90
15	8.21	6.10	5.51	4.40	2.82	2.20	.70	.70	.90	1.00	.80	2.60
16	9.67	12.30	8.51	5.01	2.69	1.70	.60	.70	.60	.90	.70	2.00
17	12.91	11.98	7.21	4.42	2.52	1.50	.60	.60	.60	.80	.70	1.80
18	10.87	11.12	9.38	4.33	2.45	2.30	.50	.60	.50	.80	.70	1.50
19	9.34	9.76	12.94	10.38	2.33	1.40	.70	.50	.50	.80	.60	1.40
20	5.91	8.32	10.72	7.82	2.20	1.30	.90	.40	.40	2.00	.60	1.40
21	5.11	8.27	9.42	5.52	2.18	1.30	1.00	.40	.30	2.80	.60	1.30
22	5.42	8.16	8.11	4.72	2.48	1.20	.80	a .00	.30	3.20	.50	1.30
23	5.10	8.10	6.42	4.61	3.67	1.00	1.30	3.30	.30	2.40	.60	1.40
24	5.37	7.13	8.65	5.48	3.35	.90	3.20	3.10	.20	1.60	1.00	6.40
25	5.31	6.28	8.85	11.87	3.01	.90	2.00	2.10	.20	1.20	1.40	5.90
26	5.01	6.13	6.93	12.41	2.40	1.20	2.00	1.20	.40	1.00	4.40	5.20
27	4.71	12.13	6.01	8.22	2.18	3.20	2.30	.80	.40	.80	5.30	3.50
28	4.69	14.91	7.87	5.84	2.12	3.20	4.30	3.00	.40	.70	4.20	2.60
29	5.03	.....	7.30	5.16	2.06	1.60	5.10	2.30	.30	1.40	3.10	2.30
30	4.90	.....	6.91	4.71	2.03	1.70	4.20	1.80	.30	1.00	2.00	2.10
31	5.07	.....	6.28	.....	2.15	.....	3.20	2.40	.....	1.10	.....	1.60

a Mud around gage.

FLINT RIVER, AT ALBANY, GEORGIA.

This river, known to the Indians as the "Thronateeska," rises in the west-central part of Georgia and flowing in a southerly direction cuts through Pine Mountain Range just below Molena. It joins the Chattahoochee to form Apalachicola River. Its drainage area is hilly and rolling on the headwaters and level at the lower end. It is largely cultivated, but most of the ground is well terraced. A station was established at Molena, Georgia, June 7, 1897. Measurements were made during 1897 and 1898, and a rating table constructed by Prof. B. M. Hall. The alternate accumulation and washing out of sediment in an eddy one-half mile below so affected the gage height that it has not been possible to establish a definite relation between them and the discharge measurements, and the station was discontinued June 2, 1898. Records of measurement made at Molena may be found as follows: 1897, Eighteenth Annual Report, Part IV, page 234; 1898, Nineteenth Annual Report, Part IV, page 233. Two measurements were made in 1899 at the Macon and Birmingham bridge, near Woodbury, Georgia, 5 miles below the old Molena station. The gage heights are assumed, based on permanent bench marks. First measurement, January 29, gage height, 0.80 foot; discharge, 590 second-feet. Second measurement, August 29, gage height, 0.57 foot; discharge, 461 second-feet.

The United States Weather Bureau has a gage rod at Reynolds, 80 miles above Albany. It was erected in 1893 by the United States Engineer Corps. The rod is attached to the middle pier of the railroad bridge, 3 miles east of the town. The drainage area above Reynolds is reported to be 2,000 square miles.

A second station has been maintained at Albany, Georgia, by the United States Weather Bureau. The drainage area at this point is, approximately, 5,000 square miles. Mr. J. B. Marbury, the local forecast official at Atlanta, Georgia, furnishes the following information:

The river gage is in two sections. the long section. from 10 to 36 feet. is nailed in two segments to the south face downstream side of the west pier, on the right or Albany side of the river; the short section is nailed to a cypress tree 120 feet down the river from the pier. The top of the pier foundation sill is 8.1 feet above low water. A second gage, reading from zero to 21 feet, is nailed to a cypress tree on the left bank of the river about 100 feet downstream from the point where the south side of Commerce street, if extended, would cross the river. The first bench mark is the top of the wide marble foundation stone of the African Methodist Episcopal Church, corner of Washington and State streets, Albany, Georgia. It is 49.5 feet above zero of gage. A second bench mark is the top of the sill of the old wharf at the foot of Broad street. It is 3 feet above low water. The observer is John E. Clark. No measurements of discharge were made in 1899 at this station.

Daily gage height, in feet, of Flint River at Albany, Georgia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.70	8.30	14.30	8.30	5.40	2.40	0.50	4.30	2.50	0.40	0.60	4.10
2	6.50	8.70	14.30	7.80	4.80	2.40	.60	4.70	2.10	.10	.70	4.30
3	6.40	8.90	15.10	7.00	4.40	2.20	.40	4.90	2.00	.20	.70	4.50
4	6.40	9.20	15.90	6.70	4.20	2.00	.20	4.90	2.30	.20	.70	4.50
5	7.30	9.60	15.90	6.40	4.10	2.00	.10	4.10	2.20	.20	.70	4.50
6	9.20	10.80	14.30	6.90	4.00	2.00	.00	3.90	2.00	.30	.70	4.20
7	10.00	11.60	13.00	7.50	3.80	2.00	.20	3.50	2.00	.90	.60	3.90
8	10.00	12.30	12.10	8.00	3.30	1.90	.40	3.30	2.00	1.30	.60	3.80
9	9.50	13.80	11.80	7.40	3.00	1.70	.00	3.00	2.10	1.60	.60	3.70
10	11.60	14.60	11.50	7.80	2.80	1.30	—.10	2.60	2.10	1.90	.50	3.50
11	13.50	15.90	10.90	8.00	2.60	1.20	—.10	2.60	2.00	2.40	.50	3.30
12	16.70	17.30	9.40	7.40	2.40	1.20	—.20	2.30	2.10	2.40	.40	3.70
13	16.80	18.20	8.30	6.90	2.00	1.20	—.30	2.20	2.20	2.40	.30	3.90
14	17.00	19.90	8.00	6.50	1.80	1.20	—.40	1.80	2.20	2.70	.30	4.10
15	17.00	21.80	7.80	5.00	1.70	.90	—.30	1.50	2.30	2.80	.60	4.30
16	17.50	19.00	8.30	5.00	1.50	.70	—.40	1.20	2.40	2.80	.70	4.30
17	18.00	17.60	8.90	5.00	1.30	.50	—.50	1.00	2.50	2.90	.80	4.00
18	18.80	16.90	9.60	5.20	1.20	.50	—.60	1.00	2.20	3.00	.80	3.80
19	17.30	15.20	10.40	5.30	1.00	.40	—.60	1.00	2.30	3.00	.90	3.60
20	16.90	14.60	11.30	5.50	.90	.40	—.60	.80	1.80	2.90	.80	3.30
21	15.30	14.30	12.80	5.50	.90	.40	—.70	.70	1.60	3.20	.80	3.10
22	14.10	13.90	11.90	5.50	.90	.30	—.70	.70	1.50	3.40	.90	3.40
23	12.30	13.20	11.60	5.50	1.00	.30	—.70	.90	1.20	3.20	.90	3.50
24	11.00	13.00	11.50	5.90	2.30	.60	—.80	1.10	1.10	2.70	1.00	3.50
25	10.20	12.00	11.30	6.70	3.80	.80	—.80	1.60	1.20	2.70	1.20	3.70
26	9.40	11.30	10.60	6.90	4.30	.90	—.30	.50	1.30	2.50	1.50	3.90
27	8.70	10.20	10.00	7.00	5.40	.90	—.70	.30	1.80	1.70	1.60	4.00
28	8.20	12.30	9.40	6.30	4.30	.80	—.90	.30	1.90	1.30	1.70	4.20
29	7.90	.....	9.20	6.00	3.80	.80	1.80	.30	1.90	.90	2.20	2.50
30	7.90	.....	8.90	5.80	3.00	1.30	1.70	.20	1.90	.70	2.60	4.90
31	7.90	.....	9.10	.....	2.50	.....	5.00	.20	.....	.50	.....	5.90

CHATTAHOOCHEE RIVER AT OAKDALE, GEORGIA.

This river rises in the northeastern part of Georgia and flows in a southwesterly direction to the boundary line between Georgia and Alabama, when it turns to the southward and forms the dividing line between these States to the southern border of Georgia, where it joins Flint River to form the Apalachicola. Its watershed above the mouth of Chestatee River is mountainous and over 80 per cent in oak forests; from thence to West Point, Georgia, it is narrow and hilly and about 50 per cent is under cultivation. From West Point to Columbus, Georgia, is through a rocky, mountainous, well-wooded country. Below Columbus, Georgia, the river is navigable, but the country is hilly, consisting of extensive high plains traversed by deep narrow valleys. The drainage area above Oakdale is entirely mapped on the following atlas sheets: Marietta, Walhalla, Dahlonega, Ellijay, Suwanee, Gainesville, and Atlanta. A large number of important water-power privileges occur on the tributaries and on the main river. The most important fall occurs near Columbus, where the river descends 120 feet in 4 miles. A fall of 362 feet from West Point to Columbus, a distance of 34 miles, occurs in a number of shoals, separated by stretches of comparatively quiet water. Elaborate surveys of shoals near Atlanta, Georgia—Vining Shoal, 32 feet, and Bull Sluice, 60 feet—have been made by companies with the object of development and electric transmission to Atlanta. Two gaging stations are maintained on the Chattahoochee River, one at Oakdale, about 8 miles

northwest of Atlanta, and the other at West Point, Georgia, where the Chattahoochee River reaches the Alabama State line. The station was established at Oakdale by Cyrus C. Babb on October 17, 1895. It is described in the Eighteenth Annual Report, Part IV, page 85. It was located at the Southern Railway bridge, 1 mile above the mouth of Proctor Creek.

On July 30, 1896, the location of the station was changed to Mason & Turners Ferry, 1 mile below Oakdale. The gage at this point, known as the "Oakdale lower gage," is nailed to a tree on the right bank, 100 feet below the ferry, and set 1 foot lower than the gage at the Southern Railway bridge. On June 1, 1899, the lower gage was discontinued and the upper gage resumed and adopted by the United States Weather Bureau, the United States Geological Survey still receiving the records and making current-meter discharge measurements at that point. The gage recently put in and now used is set on the same datum as the old wire gage of the United States Geological Survey, established at that point by Mr. Babb in 1895, and above referred to, but is a vertical, timber, rod, 3.25 inches by 6 inches by 28 feet, bolted with five iron bolts to the east side of the center pier of the Southern Railway bridge. It is well painted and is graduated into feet with brass figures and into tenths with copper nails from −1.5 feet to +26.5 feet, making its total length 28 feet. Its zero point is 753.5 feet above sea level. Bench mark No. 1 is a railroad spike in corner of pier, right bank, 12.39 feet above datum of gage. Bench mark No. 2 is top of downstream iron girder under cross-ties, 23 feet from west end of bridge, and is 54.75 feet above gage datum. The flow is obstructed by rafts, which have to be cleared from the channel occasionally. The channel is straight and the current swift. The banks are subject to overflow. The bed of the stream is constant and the results obtained fairly good. All discharge measurements made in 1899 are referred to the upper gage at the railroad bridge. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 85; 1897, Nineteenth Annual Report, Part IV, page 236; 1898, Twentieth Annual Report, Part IV, page 182. The following measurements were made during 1899 by B. M. Hall and assistants:

Measurements of Chattahoochee River at Oakdale, Georgia.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
March 11	4.35	4,397	September 9	1.32	1,452
May 1	3.80	3,452	October 6	.67	1,150
May 26	2.36	2,678	October 17	.54	1,083
June 14	3.92	4,788	November 18	.42	988

A number of miscellaneous discharge measurements were made on tributaries of Chattahoochee River by B. M. Hall and his assist-

ıts during 1899. They are as follows, arranged in geographic ·der from the headstream down: Three measurements of Soquee iver were made at Porter Mills, near Clarksville, Georgia. The rst, on May 29, showed a discharge of 342 second-feet; the second, ı June 7, gave a discharge of 239 second-feet; the third, on June 10, ıve a discharge of 231 second-feet. The measurement of Hazel reek, below the ford between Demorest and Porter Mills, on June), showed a discharge of 63 second-feet. Two measurements were ade on Chattahoochee River at Shallow Ford bridge, near Gainesllle, Georgia, 5 miles above the mouth of Chestatee River. The rst, on June 22, at a gage height of 1.30 feet, showed a discharge of 3 second-feet; the second, on October 10, at a gage height of 0.95 ot, showed a discharge of 613 second-feet. Chestatee River at New·idge post-office, Georgia, was discharging 354 second-feet on July ·. Chattahoochee River at Barkers Ferry, near Buford, Georgia, as carrying 782 second-feet on November 17. Sweetwater Creek ıters the Chattahoochee 10 miles below Oakdale, Georgia. Three easurements of its discharge were made at the Strickland bridge ·ar Austell. The first measurement, on April 19, gage height, 3.20, ıowed a discharge of 402 second-feet; the second, on June 24, gage ·ight, 1.1 feet, gave a discharge of 242 second-feet. The third meas·ement, on October 24, gave a discharge of 108 second-feet. The ree following measurements were made of Chattahoochee River, ·tween Oakdale and West Point: October 3, at Moodys bridge, ı the Owensbyville wagon road, at a gage height of 0.0 feet, the disıarge was 1,165 second-feet; on October 4 the river at Franklin, eorgia, about 40 miles above West Point, at a gage height of —0.70 ot, showed a discharge of 1,164 second-feet; on November 4 this ver at McGees bridge, about 20 miles above West Point, Georgia, a gage height of 0.40 foot, was carrying 1,670 second-feet.

Yellow Jacket Creek, at its mouth just above McGees bridge, was scharging 77 second-feet on November 4.

ıily gage height, in feet, of Chattahoochee River at Oakdale, Georgia, for 1899.

LOWER GAGE AT MASON & TURNER'S FERRY. (a)

Day.	Jan.	Feb.	Mar.	Apr.	May	Day.	Jan.	Feb.	Mar.	Apr.	May.
1	4.25	5.10	9.80	13.00	4.70	17	4.75	7.25	24.25	5.25	3.60
2	4.75	4.50	6.85	7.75	4.45	18	4.50	6.10	11.00	4.95	3.50
3	3.60	5.80	6.17	6.50	4.40	19	4.10	5.60	10.50	5.00	3.55
4	3.40	4.90	5.00	7.75	4.35	20	3.90	4.90	15.00	4.95	3.50
5	3.10	6.50	8.10	6.50	4.50	21	3.75	5.25	8.75	4.85	3.45
6	3.75	10.00	8.50	5.90	5.10	22	3.60	5.20	7.25	4.65	5.50
7	6.75	16.00	6.40	6.50	4.00	23	3.90	5.00	9.50	4.75	3.60
8	6.10	21.50	5.90	7.75	4.35	24	4.25	4.90	9.00	4.95	3.50
9	5.25	13.40	5.50	7.50	4.25	25	4.10	4.60	6.50	7.25	3.35
10	4.70	9.50	5.25	7.10	4.10	26	4.25	10.23	7.10	8.00	3.25
11	6.30	6.40	5.10	6.80	4.00	27	3.70	22.13	6.20	6.25	3.15
12	4.75	5.50	5.00	5.75	3.95	28	3.45	18.88	6.10	5.25	3.10
13	4.25	4.90	4.95	5.25	3.90	29	3.25	.....	7.90	5.00	3.20
14	4.50	4.10	6.25	5.20	3.85	30	3.50	.....	6.45	4.80	6.10
15	5.50	4.00	10.00	5.10	3.80	31	4.65	.....	12.30	.....	3.40
16	4.90	5.00	21.50	5.00	3.70						

a Discontinued May 31.

UPPER GAGE AT SOUTHERN RAILWAY BRIDGE.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	2.45	1.50	1.70	4.60	0.40	0.60	1.30	17...	2.05	0.80	0.60	0.50	0.50	0.60	1.60
2..	2.40	1.40	1.40	2.70	.10	.50	1.80	18...	2.05	1.00	.60	.30	.60	.50	1.30
3..	2.30	1.35	1.20	2.10	.10	.50	1.50	19...	2.00	1.30	.50	.40	.60	.50	1.10
4..	2.10	1.25	1.10	1.90	.10	.50	1.40	20...	1.90	1.00	.40	.40	.80	.40	1.20
5..	2.05	1.20	1.10	1.60	.40	.50	1.10	21...	1.75	1.35	.40	.40	.90	.40	1.10
6..	2.00	1.40	1.00	1.00	.60	.40	.90	22...	1.70	3.80	.40	.40	.70	.90	1.10
7..	2.00	1.40	.90	.90	1.60	.40	.80	23...	1.55	2.30	.30	.30	.60	2.00	3.40
8..	2.05	1.40	.80	.80	1.50	.40	.80	24...	1.55	1.90	.20	.30	.50	2.40	5.50
9..	2.05	1.40	.70	.70	2.00	.40	.80	25...	1.80	.80	.10	.30	.50	1.70	4.60
10..	2.10	1.30	.60	.70	1.20	.40	.80	26...	2.05	2.10	.20	.30	.40	3.00	3.40
11..	2.15	1.30	.60	3.00	.90	.40	.70	27...	2.20	2.10	5.20	.20	.50	2.80	2.40
12..	2.75	1.10	.50	1.10	.70	.70	2.20	28...	2.00	5.90	3.40	.20	.50	2.70	2.00
13..	4.80	1.10	.50	.90	.70	.50	6.40	29...	1.80	3.40	1.40	.20	.90	2.10	2.10
14..	4.00	.90	.50	.80	.70	.50	3.10	30...	1.60	3.30	3.20	.20	.70	1.80	1.80
15..	2.90	.80	.50	.70	.60	.50	2.40	31...	.....	3.20	2.80	.....	.60	.....	1.70
16..	2.25	.80	.60	.60	.50	.60	1.80								

CHATTAHOOCHEE RIVER AT WEST POINT, GEORGIA.

This station was established July 30, 1896, by Max Hall, and is at the highway bridge in West Point, Georgia, about 1,200 feet above the railroad passenger station. A wire gage is suspended from the bridge and referred to four bench marks. First bench mark, downstream end, top of first iron-floor beam from the west bank pier of highway bridge, elevation 24.01 feet above datum; second bench mark, downstream end, top of second iron-floor beam from west bank pier of the highway bridge, elevation 24.19 feet above datum; third bench mark, top of second stone pier, Atlanta and West Point Railroad bridge, 1,000 feet upstream, elevation 24.65 feet; fourth bench mark, notch in large oak tree, east bank of river, 100 feet above wagon bridge, elevation 19.26 feet. The length of the wire gage is 33.46 feet. The gage was last verified March 14, 1899. The channel is straight and without obstructions, except from the piers of the bridge. The flow is sluggish in low stages of water. The banks overflow at high water, but all ordinary stages of water pass through the main channel. The bed of the stream is fairly constant. The observer is C. P. Jennings, a clerk in the Atlanta and West Point freight depot. He is paid by the United States Weather Bureau. The results of measurements at West Point may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 92; 1897, Nineteenth Annual Report, Part IV, page 239; 1898, Twentieth Annual Report, Part IV, page 183. The following measurements were made by B. M. Hall and his assistants during 1899:

March 14, gage height, 5.30 feet; discharge, 8,726 second-feet.
April 24, gage height, 4.72 feet; discharge, 7,144 second-feet.
May 13, gage height, 3.80 feet; discharge, 4,828 second-feet.
June 26, gage height, 3.06 feet; discharge, 3,234 second-feet.
September 12, gage height, 3.10 feet; discharge, 3,689 second-feet.
October 18, gage height, 2.07 feet; discharge, 2,088 second-feet.
December 16, gage height, 3.49 feet; discharge, 4,111 second-feet.

gage height, in feet, of Chattahoochee River at West Point, Georgia, for 1899.

ay.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.30	4.50	14.50	10.00	4.30	3.60	3.00	2.50	2.40	1.10	2.10	4.40
2	4.35	4.65	12.70	7.70	4.20	3.30	2.80	2.30	2.00	1.30	2.10	4.30
3	4.20	10.20	6.50	7.00	4.10	3.20	2.70	2.80	2.90	1.30	1.90	3.40
4	4.10	8.30	5.80	7.15	3.90	3.10	2.50	2.80	2.40	1.10	1.90	3.40
5	4.00	7.20	6.40	6.70	3.80	3.00	2.40	2.70	2.10	1.40	1.90	3.40
6	4.00	5.80	7.00	6.40	3.75	3.00	2.40	2.80	3.00	1.50	1.90	3.20
7	5.50	9.10	6.10	6.90	3.75	2.90	2.40	2.80	2.90	1.80	1.90	3.10
8	5.75	13.30	5.60	7.30	3.70	2.80	2.80	2.70	2.00	2.40	1.90	3.10
9	5.50	13.00	5.20	6.80	3.80	2.80	2.90	2.40	1.90	2.70	1.90	2.90
0	5.60	9.05	5.00	6.30	4.00	3.00	3.00	2.30	2.90	2.60	1.90	2.60
1	7.00	6.30	4.90	6.00	3.80	3.10	3.20	2.10	2.50	2.30	1.90	2.40
2	8.80	5.90	4.85	5.40	3.70	3.20	2.50	2.20	2.10	2.30	1.90	3.50
3	5.90	5.20	4.90	5.15	3.65	3.80	2.30	2.30	2.40	2.10	1.90	4.00
4	5.40	4.75	5.00	5.10	3.65	4.00	2.30	2.40	2.00	1.90	1.90	4.60
5	6.00	5.00	5.10	5.05	3.65	4.10	2.30	2.00	2.80	2.40	2.10	4.10
6	5.20	5.20	10.50	5.00	3.60	3.60	2.10	2.50	2.40	2.50	2.20	3.60
7	5.00	5.10	12.30	4.95	3.60	3.10	2.30	3.00	1.60	2.30	2.20	3.10
8	4.90	4.60	13.50	4.90	3.50	3.00	2.30	3.20	1.60	2.30	2.10	3.00
9	4.75	4.30	12.10	4.80	3.20	2.90	2.50	2.80	1.60	2.60	2.10	2.80
0	4.50	4.00	10.75	4.60	3.10	2.80	2.70	2.40	1.50	2.90	2.10	2.80
1	4.20	3.75	8.20	4.45	3.10	2.80	3.00	2.60	1.70	3.30	2.10	2.80
2	4.10	3.60	7.50	4.60	3.05	2.60	3.60	2.90	1.90	2.40	1.90	2.80
8	4.05	3.60	6.90	4.65	3.05	2.50	4.20	3.00	2.30	2.40	2.00	3.20
4	3.90	3.50	7.20	4.70	4.80	2.70	4.70	3.20	1.10	2.30	2.20	6.00
5	3.60	3.50	7.00	4.80	4.10	2.90	3.60	3.50	1.20	2.50	3.00	5.70
6	3.60	3.50	6.50	5.60	3.80	3.40	3.00	2.00	1.20	2.10	3.10	5.60
7	3.50	10.70	6.20	6.05	3.10	3.50	3.20	2.50	1.20	2.00	3.40	4.10
8	3.65	15.20	6.15	5.10	3.40	3.20	5.90	3.10	1.30	2.10	3.20	3.60
9	3.75	.....	6.80	5.00	3.30	3.00	3.30	3.60	1.80	2.10	3.50	3.40
0	4.00	.....	6.30	4.70	3.25	3.20	2.90	2.90	1.90	2.20	4.20	3.30
1	4.75	.....	7.15	.....	4.00	.....	2.70	2.10	.....	2.10	.....	3.20

station has been maintained by the United States Weather Bureau ufaula, Alabama, 80 miles below West Point. The rod is attached ie west side of brick pier of wagon bridge. The top of brick foun- on of pier on west bank is 48.5 feet above gage datum. The nage area above this point is reported to be 6,900 square miles.

ETOWAH RIVER AT CANTON, GEORGIA.

he headwaters of this stream adjoin those of Chattahoochee River the east, and the headwater tributaries of Coosawattee River on west. Its drainage area is on the southern slope of the Blue ge Mountains, and it flows westerly into the Gulf drainage. A nber of fine water powers occur throughout its length, the one at tersville, where it crosses the western fall line, being especially ed. This river joins the Oostanaula at Rome, Georgia, to form sa River. Its drainage basin is mapped on the following atlas ets: Ellijay, Cartersville, and Suwanee. The gaging station was ablished by the United States Weather Bureau March 12, 1892. It ocated at the iron highway bridge over the Etowah River, about 00 feet north of and upstream from the Atlanta, Knoxville and thern Railway station, Canton, Georgia, and about one-half a e above the mouth of Canton Creek. The bench mark is the top ne of the four pieces of track iron which forms a cap on the left r, upstream side, and on which the bridge rests, and is at an eleva- n of 23.30 feet above datum. Up to about 14 feet the river is con-

fined between its banks, but above this stage the river begins to overflow the bottom lands. The reports of discharge measurements are found as follows: 1896, Eighteenth Annual Report, Part IV, page 95; 1897, Nineteenth Annual Report, Part IV, page 242; 1898, Twentieth Annual Report, Part IV, page 189. The following measurements were made by B. M. Hall and his assistants in 1899:

April 27, gage height, 1.92 feet; discharge, 2,087 second-feet.
June 23, gage height, 0.25 foot; discharge, 770 second-feet.
September 27, gage height, —0.19 foot; discharge, 406 second-feet.
November 10, gage height, —0.10 foot; discharge, 420 second-feet.

Long Swamp Creek enters Etowah River 13 miles above Canton, Georgia. On April 21 it was measured at Revis Bridge, near Ballground, Georgia, and showed a discharge of 188 second-feet. Fourmile Creek, a tributary of Long Swamp Creek, was measured April 21 near Ballground, Georgia, and showed a discharge of 20 second-feet. Sharp Mountain Creek enters the Etowah 8½ miles above Canton. On November 10 a measurement of this stream, made by B. M. Hall near Ballground, Georgia, showed a discharge of 34 second-feet.

Daily gage height, in feet, of Etowah River at Canton, Georgia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	1.60	3.00	2.40	1.60	1.00	1.40	1.40	0.80	—0.40	—0.10	0.10
2	1.80	1.60	2.80	2.20	1.50	1.40	1.40	1.40	.60	—.40	—.10	.40
3	1.80	1.80	2.80	2.00	1.40	1.40	1.40	1.80	.60	—.50	—.10	.40
4	1.80	2.80	2.60	3.80	1.40	4.40	1.20	1.60	.60	—.50	—.10	.40
5	1.80	3.00	2.40	3.00	1.40	3.00	1.20	1.60	.60	—.50	—.10	.20
6	1.80	6.20	2.00	2.80	1.40	1.00	1.00	1.40	.60	.00	—.10	.20
7	1.60	8.00	1.80	2.80	1.40	1.00	1.40	1.20	.50	.20	—.10	.20
8	1.40	4.00	1.80	4.00	1.40	1.00	1.60	1.60	.50	.20	—.10	.20
9	1.40	3.20	1.60	3.00	1.60	1.00	4.00	1.80	.40	.20	—.10	.20
10	1.40	3.00	1.50	2.80	1.60	1.00	2.00	1.60	.40	.10	—.10	.20
11	1.40	2.00	1.50	2.00	1.40	1.40	1.80	1.60	.40	.10	—.10	.30
12	1.80	(a)	1.40	1.80	1.40	1.60	1.60	1.60	.40	.10	—.10	.80
13	1.80	(a)	1.40	1.80	1.40	1.60	1.40	1.40	.40	.00	—.10	.80
14	2.80	(a)	3.60	1.80	1.80	1.40	1.40	1.20	.40	.00	—.10	.30
15	2.60	3.00	7.00	1.80	1.80	1.40	1.80	1.20	.40	.00	.00	.20
16	2.40	2.00	18.20	1.60	1.80	1.40	1.90	1.00	.40	.00	.00	.20
17	2.30	2.00	18.00	1.60	1.60	1.40	1.80	1.00	.30	.00	.10	.20
18	2.30	2.00	4.00	1.60	1.60	1.40	1.80	.80	.30	.00	.00	.10
19	2.20	2.00	4.00	1.40	1.60	1.40	1.80	.80	.30	.00	.00	.10
20	2.20	1.80	3.00	1.40	1.40	1.30	1.60	1.40	.20	—.10	.00	.10
21	2.00	1.80	2.00	1.40	1.40	1.30	1.60	1.40	.10	—.10	.00	.10
22	1.80	1.80	2.00	1.40	1.40	1.30	1.60	1.20	.00	—.10	.00	.10
23	1.80	1.80	2.00	1.40	1.40	1.20	1.60	1.00	.00	—.10	.90	.80
24	2.00	1.60	1.80	1.80	1.40	1.20	1.40	1.00	.00	—.10	.70	3.00
25	2.80	1.40	1.80	4.80	1.40	1.20	1.20	.80	—.10	—.10	.70	3.00
26	2.00	1.80	2.80	3.00	1.20	1.00	1.20	.80	—.10	—.10	1.10	2.00
27	1.80	10.00	2.00	2.80	1.20	1.00	1.20	1.40	—.10	.00	.70	2.30
28	1.80	5.00	1.80	2.00	1.20	1.00	1.20	1.20	—.20	.00	.50	1.80
29	1.80	.....	2.80	1.80	1.20	1.00	1.20	1.00	—.30	—.10	.10	.60
30	10.00	.....	2.00	1.70	1.20	1.00	1.10	1.00	—.30	—.10	.10	.60
31	5.00	.....	2.60	.....	1.00	.....	1.00	.80	.....	—.10	.....	.60

a Gage covered with ice.

COOSAWATTEE RIVER AT CARTERS, GEORGIA.

This river is formed by the junction of Ellijay and Cartecay rivers at Ellijay, Georgia, and flows in a southwesterly direction, joining the Conasauga to form the Oostanaula. Its drainage area is for the

most part mountainous and covered with forest growth. The station was established August 15, 1896, at the iron highway bridge at Carters, Murray County, Georgia, about 20 miles northeast of Calhoun, the most convenient railroad station. It is described in the Eighteenth Annual Report, Part IV, page 96. Carters is the head of navigation, small boats running to Rome, Georgia, and the Coosa River below. It is at the foot of the great shoals made by this stream in cutting through the Cohutta Mountains, the last of which is Carters Shoals, a short distance above the bridge, with a fall of 50 feet. The drainage area above this point is 532 square miles, of which 150 square miles is on the Talking Rock Creek, which enters the river one-half mile above. The basin is mapped on Dalton, Ellijay, Cartersville, and Suwanee atlas sheets. The length of the wire gage is 37.24 feet. The top of the cylindrical iron pier at the right-bank downstream corner of bridge is 30.35 feet above gage datum. The gage was last verified in August, 1898. The current is swift, but is broken by a gravel bar above the section. The bed is gravelly and not apt to change. The banks are high, but occasionally overflow in high water. The observer, H. S. Weems, merchant at Carters, Georgia, gives his services to the Survey without compensation. Records of measurement may be found as follows: 1896 and 1897, Nineteenth Annual Report, Part IV, page 244; 1898, Twentieth Annual Report, Part IV, page 191. The following measurements were made by O. P. Hall and Max Hall in 1899:

January 28, gage height, 2.14 feet; discharge, 868 second-feet.
March 14, gage height, 8.95 feet; discharge, 5,240 second-feet.
March 14, gage height, 7.70 feet; discharge, 4,682 second-feet.
May 26, gage height, 2.35 feet; discharge, 906 second-feet.
June 22, gage height, 1.75 feet; discharge, 653 second-feet.
October 19, gage height, 1.10 feet; discharge, 377 second-feet.

A number of measurements of the tributaries of Coosawattee River have been made during the past season. Ellijay River, at the wagon bridge near Ellijay, Georgia, was measured on October 13, and showed a discharge of 80 second-feet. Talking Rock Creek, which enters Coosawattee River just above Carters Station, was measured twice during the year, the first time on May 26, when the discharge was 144 second-feet, and the second time on June 22, when the discharge was 114 second-feet. April 22 Scared Corn Creek, a tributary of Talking Rock Creek, was discharging 32 second-feet. Sallacoa Creek, which enters Coosawattee River from the south 1 mile above Fields Mill Ferry, was measured on May 20, when the discharge was found to be 103 second-feet. Coosawattee River itself at Fields Mill Ferry, 5½ miles above its junction with the Conasauga, was measured October 14, showing a discharge of 388 second-feet.

Daily gage height, in feet, of Coosawattee River at Carters, Georgia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	2.50	5.00	5.10	3.40	2.00	1.40	1.90	1.00	0.75	0.95	0.95
2	1.90	3.00	4.50	5.00	3.30	1.95	1.50	1.80	1.05	.75	.90	1.30
3	1.90	3.50	3.50	5.20	3.20	1.95	1.40	1.80	1.00	.70	.90	1.20
4	2.00	15.80	3.50	6.00	3.00	1.90	1.40	1.70	1.00	.65	.90	1.20
5	2.05	14.00	6.10	5.80	2.90	2.00	1.45	1.60	.95	.65	.85	1.10
6	2.10	13.20	4.80	5.50	2.90	2.00	1.40	1.50	1.00	.70	.85	1.00
7	2.00	12.50	4.50	5.50	2.80	1.90	1.30	1.45	.95	.70	.80	1.10
8	3.00	8.00	4.00	4.80	2.70	1.90	1.30	1.50	.90	1.50	.80	1.00
9	2.00	6.00	3.20	4.00	2.65	1.85	1.60	1.50	.90	1.20	.90	.90
10	2.00	6.00	3.00	3.70	2.60	1.85	1.50	1.40	.90	1.00	.80	.90
11	2.10	5.00	3.50	3.60	2.50	1.90	1.50	1.40	.95	.90	.80	1.10
12	2.00	4.00	3.50	3.50	2.50	3.20	1.40	1.30	.90	.90	.90	7.40
13	1.90	4.00	4.00	3.40	2.60	3.00	1.40	1.30	.90	.95	.90	5.00
14	1.90	4.50	4.50	3.00	2.60	2.50	1.40	1.60	.90	.90	1.00	3.00
15	2.00	4.50	19.00	3.00	2.50	2.30	1.35	1.50	.85	.90	.90	2.00
16	2.20	4.00	12.00	3.10	2.50	2.20	1.30	1.40	.85	.90	.90	1.50
17	2.80	5.00	10.00	4.00	2.40	2.10	1.70	1.20	.85	.90	1.00	1.30
18	2.60	4.70	9.00	4.00	2.30	2.00	1.50	1.20	.80	.85	1.05	1.10
19	2.40	3.60	7.50	3.75	2.30	1.90	1.60	1.15	.85	.85	1.00	1.10
20	2.30	3.50	6.00	3.50	2.20	1.90	1.80	1.15	.85	.90	1.10	1.20
21	2.10	4.00	5.00	3.40	2.20	1.80	2.20	1.10	.80	.90	1.10	1.20
22	2.10	3.50	8.00	3.50	2.30	1.70	3.00	1.10	.80	.90	1.00	1.40
23	2.00	3.40	7.00	3.50	2.20	1.70	2.50	1.10	.85	.85	.90	1.50
24	2.00	3.50	6.50	4.00	2.15	1.70	2.00	1.05	.85	.85	1.00	3.00
25	2.50	4.00	5.00	6.00	2.15	1.60	2.00	1.05	.80	.80	1.00	2.00
26	2.30	5.00	5.00	5.00	2.10	1.60	3.20	1.10	.80	.80	1.20	1.50
27	2.10	15.00	5.20	4.00	2.10	1.50	3.00	1.10	.80	.75	1.10	1.30
28	2.10	7.00	4.80	4.00	2.05	1.50	3.00	1.05	.80	.80	1.05	1.20
29	2.10	.....	4.50	3.70	2.05	1.40	2.20	1.15	.75	1.00	1.00	1.20
30	2.20	.....	4.60	3.60	2.00	1.45	1.90	1.20	.80	1.00	1.00	1.10
31	2.40	.....	4.40	.....	2.00	.....	2.00	1.10	.....	.90	.....	1.10

OOSTANAULA RIVER AT RESACA, GEORGIA.

This river is formed about 3 miles above Resaca by the junction of Coosawattee and Conasauga rivers, the former having a drainage area of 875 and the latter 648 square miles, while there are 4 square miles between the junction and Resaca. This gives a total drainage area of 1,527 square miles, mapped on atlas sheets Cleveland, Ellijay, Dalton, Cartersville, and Suwanee. The station is at the iron railroad bridge of the Western and Atlantic Railroad, in the town of Resaca, Georgia, 1,000 feet from the depot. On July 27, 1896, a discharge measurement was made by Max Hall, and a station established using the Weather Bureau gage. On August 19 a wire gage was established and referred to the same datum. The initial point is the right bank end iron of bridge, downstream side. The length of the wire gage is 43.40 feet. The first bench mark is on the top of capstone of center pier, at an elevation of 36.12 feet; the second is the top of crosstie near center, at an elevation of 40.12 feet. The channel is straight and the current fairly swift. The bed is soft and liable to change; the banks somewhat subject to overflow. The observer is S. M. Barnett, railroad agent at station, who is also the observer for the Weather Bureau. Records of measurement may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 98; 1897, Nineteenth Annual Report, Part IV, page 245; 1898, Twen-

ieth Annual Report, Part IV, page 190. The following measurements vere made by Olin P. Hall and Max Hall during 1899:

April 26, gage height, 8.05 feet; discharge, 5,146 second-feet.
May 20, gage height, 4.15 feet; discharge, 1,671 second-feet.
June 9, gage height, 3.10 feet; discharge, 1,171 second-feet.
June 21, gage height, 3.05 feet; discharge, 1,087 second-feet.
October 14, gage height, 1.75 feet; discharge, 644 second-feet.

Three measurements of the discharge of Conasauga River at Fites Ferry, 3½ miles above its mouth, were made during the season. The irst, on June 9, gave a discharge of 224 second-feet; second, on June 21, gave a discharge of 258 second-feet, and the third, on October 14, gave a discharge of 122 second-feet.

Daily gage height, in feet, of Oostanaula River at Resaca, Georgia, for 1899 (a).

Day.	Jan.	Feb.	Mar.	Apr.	Nov.	Dec.	Day.	Jan.	Feb.	Mar.	Apr.	Nov.	Dec.
1	5.10	11.00	16.20	13.40	1.80	2.30	17	6.10	12.10	28.60	6.20	2.00	3.30
2	5.00	8.80	9.60	10.30	1.70	2.50	18	6.25	11.40	27.30	6.00	1.80	2.80
3	4.50	7.95	8.00	8.40	1.70	2.60	19	5.65	10.20	26.60	6.10	1.80	2.70
4	4.20	16.00	7.40	8.10	1.70	2.30	20	5.10	9.55	26.20	6.00	1.80	3.50
5	4.10	19.90	9.30	10.20	1.70	2.20	21	4.85	8.10	27.30	5.80	1.70	4.40
6	4.50	21.90	10.40	9.00	1.70	2.10	22	4.70	8.20	25.20	5.60	1.70	3.60
7	7.50	25.50	9.40	8.90	1.60	2.00	23	4.50	8.65	21.10	5.40	2.30	3.30
8	9.35	26.50	7.50	14.30	1.60	2.00	24	4.55	7.70	17.00	6.40	2.80	8.10
9	8.80	25.50	6.80	13.90	1.60	1.90	25	5.50	6.90	11.00	8.60	2.30	8.10
10	6.20	22.20	6.60	12.70	1.60	2.00	26	5.30	6.40	9.00	8.70	2.70	6.00
11	5.85	15.80	6.40	8.90	1.60	2.10	27	4.80	17.50	8.60	7.00	3.80	4.30
12	6.00	8.20	6.10	7.80	1.70	5.10	28	4.55	20.20	7.90	6.30	3.40	3.80
13	5.80	7.00	6.00	7.40	1.70	8.00	29	4.40	.....	11.65	5.80	2.80	3.70
14	5.30	6.35	8.00	7.00	1.70	6.40	30	4.20	.....	11.40	5.50	2.50	3.50
15	5.50	6.70	16.00	6.80	1.60	4.00	31	6.10	.....	11.40	.....	.....	3.00
16	5.15	6.70	22.00	6.50	1.90	3.60							

a No records from May 1 to October 31.

MEASUREMENTS OF LARGE SPRINGS IN NORTHWEST GEORGIA.

In the basin of Sallacoa Creek, a tributary of Coosawattee River, and in the adjoining basin of Oothkalooga Creek, are a number of large springs which were measured by Olin P. Hall in 1899. On May 30 Dooley Spring, 3 miles south of Fairmount, Georgia, gave a discharge of 0.92 second-foot; Doves Mill Spring, near Cash, Georgia, 16.2 second-feet; Bakers Mill Spring, 5 miles south of Fairmount, Georgia, 3.9 second-feet. June 24 a number of springs in the basin of Sallacoa Creek showed discharges as follows: Colima Spring, near Colima, Georgia, 0.28 second-foot; Arnold Spring, 1 mile south of Colima, 0.38 second-foot; J. R. Byrd's spring, 2½ miles northwest of Fairmount, Georgia, 0.47 second-foot; R. W. Lander's spring, 3 miles east of Pinelog, Georgia, 4.27 second-feet; J. A. Johnson's spring, 2½ miles east of Pinelog, Georgia, 0.48 second-foot; Oakhill Church Spring, 2½ miles east of Pinelog, Georgia, 1.85 second-feet.

The five following springs occur in the basin of Oothkalooga Creek, which enters Oostanaula River 1 mile below Calhoun. On June 26 heir discharge was measured and found to be as follows: Hayse

Spring, at Folsom, Georgia, 0.35 second-foot; Cedar Spring, at Mostetters Mill, 1¼ miles west of Folsom, 4.45 second-feet; Trimble Spring, 2 miles north of Adairsville, Georgia, 2.35 second-feet; Gardners Spring, 5 miles north of Adairsville, 0.41 second-foot; Blackwood Spring, 5 miles southeast of Calhoun, Georgia, 1.00 second-foot.

COOSA RIVER AT ROME, GEORGIA.

Coosa River is formed by the junction of Etowah and Oostanaula rivers at Rome, Georgia. The drainage area is 3,720 square miles. Both of the tributary rivers rise in the northern part of Georgia and flow for the most part through a hilly, broken country, well wooded, about one-fourth of the land being under cultivation. The Coosa River flows in a southwesterly direction into Alabama and joins the Tallapoosa 6 miles above Montgomery, Alabama, to form Alabama River. Measurements of flow are made at Rome and at Riverside, 120 miles farther downstream, and will be made in 1900 at Montgomery and Selma. The measurements at Rome are made on the Oostanaula and Etowah just above their junction. Etowah River is measured at Second avenue bridge and the Oostanaula at Fifth avenue bridge in Rome, and the results added to give the flow of Coosa River. The gage height is taken from the United States Weather Bureau gage at Fifth avenue bridge, on the Oostanaula. There is practically no fall on Oostanaula River from Fifth avenue bridge to the junction, hence the gage is used as Coosa River gage and gives the fluctuations of Coosa River. This gage is a 4 by 6 inch timber, graduated to feet and tenths and fastened to the downstream left-hand corner of the first pier from the left bank. The zero of gage is 575.79 feet above sea level. The United States Weather Bureau has maintained the station here for many years. It is now maintained only as a half-year station, from November 1 to April 30, inclusive, but W. M. Towers, the river observer, kindly reads the gage and furnishes the Survey with monthly reports of the daily gage heights for the entire year without charge. Mr. Towers has kept the records for many years and has predicted floods with great precision. The channel of the Etowah is straight, current swift and unobstructed, but the Oostanaula is rather sluggish and somewhat obstructed by piers. The banks are high, but liable to overflow in times of high water. Records of measurements may be found as follows: 1897, Nineteenth Annual Report, Part IV, page 198; 1898, Twentieth Annual Report, Part IV, page 184. The following measurements have been made by Max Hall and others during 1899:

January 25, gage height, 3.80 feet; discharge, 6,540 second-feet.
January 25, gage height, 3.60 feet; discharge, 5,932 second-feet.
May 19, gage height, 2.75 feet; discharge, 4,394 second-feet.
June 16, gage height, 2.40 feet; discharge, 3,352 second-feet.
August 4, gage height, 1.45 feet; discharge, 2,835 second-feet.
October 13, gage height, 0.60 foot; discharge, 1,769 second-feet.

Daily gage height, in feet, of Coosa River at Rome, Georgia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.00	6.90	19.70	13.20	4.00	3.00	1.70	2.20	3.40	0.40	0.7	1.1
2	3.40	7.80	15.00	10.60	3.70	2.60	1.50	1.90	2.00	.30	.6	1.1
3	3.00	6.00	8.60	7.90	3.70	2.60	1.00	1.70	1.60	.30	.5	1.5
4	2.70	9.20	6.60	7.20	3.50	2.00	.90	1.50	1.40	.30	.5	1.3
5	2.60	15.30	7.80	9.50	3.50	2.00	2.00	1.40	1.30	.30	.4	1.1
6	2.60	18.20	9.00	8.20	3.50	2.00	1.90	1.50	1.30	.50	.4	1.0
7	3.60	27.80	8.00	8.20	3.70	2.00	1.90	1.60	1.20	.70	.3	.9
8	5.90	24.00	6.80	15.00	3.70	1.90	3.00	1.50	1.00	.70	.3	.8
9	5.90	22.40	5.70	13.40	3.60	1.80	2.10	1.80	1.00	.80	.3	.8
10	4.90	21.00	5.40	11.20	3.50	1.80	1.90	1.60	1.00	.60	.3	.8
11	4.00	19.00	5.20	9.50	3.30	1.80	2.50	1.40	2.90	1.00	.3	.8
12	4.50	16.50	4.90	7.00	3.10	2.20	2.80	1.40	2.30	.90	.3	2.8
13	4.00	7.00	4.50	6.40	3.10	3.80	2.00	1.20	1.50	.70	.3	6.1
14	3.80	5.00	6.00	5.90	3.00	4.00	1.60	1.10	1.00	.70	.4	5.0
15	3.60	5.00	16.60	5.60	3.00	3.50	1.30	1.30	.90	.60	.4	3.2
16	3.60	5.50	27.70	5.40	2.90	2.50	1.80	1.90	.80	.60	.5	2.0
17	4.00	8.90	29.20	5.20	2.80	2.10	5.20	1.00	.60	.60	.9	1.8
18	4.20	9.50	25.80	4.80	2.80	2.00	4.20	1.40	.60	.60	.7	1.7
19	4.00	8.50	24.90	4.70	2.80	2.00	4.80	1.10	.60	.60	.5	1.3
20	3.70	7.70	26.20	4.60	2.80	2.00	8.80	.90	.70	.60	.5	1.6
21	3.30	6.80	24.60	4.30	2.60	1.80	12.80	.90	.70	.70	.5	2.0
22	3.20	6.90	23.00	4.10	2.60	2.20	7.90	.80	.60	.70	.4	2.0
23	3.10	7.30	22.60	4.00	2.40	1.70	4.80	.80	.60	.60	1.0	1.8
24	3.50	6.60	21.90	5.40	2.60	1.70	3.90	.70	.50	.50	2.1	7.2
25	3.80	5.80	18.00	7.40	2.50	1.70	2.60	.70	.50	.40	1.5	7.5
26	3.80	5.50	10.50	9.10	2.40	1.70	2.60	.70	.50	.40	2.5	5.0
27	3.30	19.10	7.70	6.70	2.20	2.10	3.80	2.50	.50	.40	3.0	3.5
28	3.00	23.40	6.80	5.50	2.20	1.90	3.00	2.50	.60	.40	2.2	3.0
29	3.00	.....	8.80	4.80	2.00	1.90	2.40	2.50	.50	.40	1.9	3.0
30	2.90	.....	9.30	4.20	2.00	1.80	1.40	2.00	.40	.50	1.4	3.4
31	4.40	.....	10.20	.....	3.30	.....	1.20	2.50	.....	.80	.....	2.0

COOSA RIVER AT RIVERSIDE, ALABAMA.

This station, described in the Eighteenth Annual Report, Part IV, page 99, was established September 25, 1896, at the bridge of the Southern Railway across Coosa River near Riverside, Alabama. The drainage area is 6,850 square miles. It is mapped on the Springville, Anniston, Gadsden, Fort Payne, Rome, Tallapoosa, Marietta, Cartersville, Suwanee, Ellijay, Dalton, Cleveland, Ringgold, and Stevenson atlas sheets. The town of Riverside is on the west bank of the river, and the railroad station is 1,000 feet west of the bridge at which the measurements are made. The length of the gage wire is 38.35 feet. The first bench mark is the top capstone on the large circular center pier of turn-span, the elevation of which is 26.80 feet above gage datum; second bench mark is base of rail near same pier, and is 32.80 feet above gage datum. The channel is straight, current swift, but somewhat obstructed by a ledge of rock under water about 300 feet above the station. The observer is J. W. Foster, Riverside, Alabama. The records of measurement may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 101; 1897, Nineteenth Annual Report, Part IV, page 248; 1898, Twentieth Annual Report, Part IV, page 187. The following measurements were made by Max Hall and others during 1899:

April 26, gage height, 9.00 feet; discharge, 29,069 second-feet.
May 3, gage height, 4.05 feet; discharge, 10,592 second-feet.
May 20, gage height, 2.70 feet; discharge, 6,276 second-feet.
June 14, gage height, 2.20 feet; discharge, 5,010 second-feet.

August 26, gage height, 1.42 feet; discharge, 3,791 second-feet.
September 23, gage height, 1.00 foot; discharge, 2,457 second-feet.
November 7, gage height, 0.85 foot; discharge, 2,271 second-feet.
December 9, gage height, 1.20 feet; discharge, 2,727 second-feet.

Daily gage height, in feet, of Coosa River at Riverside, Alabama, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	5.90	12.10	10.30	5.00	2.70	1.70	3.95	2.30	0.90	0.95	2.60
2	2.75	6.30	12.20	10.20	4.50	2.80	1.70	3.00	2.40	.90	.95	2.00
3	2.75	7.50	12.30	10.00	4.20	2.80	1.65	2.30	2.80	.90	.95	1.60
4	2.80	7.40	12.10	9.80	3.95	2.60	1.60	2.00	2.40	.90	.95	1.50
5	2.80	9.10	10.10	8.90	3.80	2.30	1.50	1.90	2.10	.90	.95	1.45
6	3.00	12.10	9.00	8.75	3.75	2.10	1.50	1.75	2.00	.90	.95	1.40
7	3.50	14.10	8.00	9.00	3.60	2.00	1.45	1.65	1.85	.90	.95	1.35
8	4.30	14.30	7.50	10.00	4.00	2.00	1.40	1.50	1.40	.90	.95	1.30
9	4.20	14.30	7.25	12.30	3.85	1.95	1.70	1.50	1.30	.95	.95	1.30
10	4.40	14.10	7.00	12.00	3.60	1.95	1.60	1.55	1.25	1.20	.95	1.35
11	5.20	13.80	6.15	11.70	3.45	1.95	1.50	1.55	1.25	1.30	.95	1.40
12	5.90	13.00	5.20	10.00	3.30	1.95	1.50	1.60	2.20	1.40	.95	5.80
13	5.60	12.00	5.50	8.90	3.20	2.00	1.40	1.50	2.50	1.30	.95	8.25
14	5.00	10.90	7.50	7.90	3.00	2.15	1.40	1.45	2.65	1.20	1.00	8.00
15	4.70	8.70	8.30	6.30	3.00	2.80	1.30	1.50	2.00	1.20	1.00	6.00
16	4.90	7.90	16.00	5.55	2.95	3.20	1.30	1.50	1.40	1.20	1.00	4.50
17	5.00	7.60	17.40	5.25	2.95	2.95	1.30	1.50	1.25	1.10	1.00	3.75
18	4.90	7.80	17.00	5.10	2.80	2.50	1.20	1.55	1.20	1.00	1.00	3.60
19	4.70	8.10	16.50	5.00	2.80	2.25	1.30	1.50	1.20	.95	1.00	3.40
20	4.60	8.20	16.30	4.80	2.75	2.00	1.50	1.45	1.10	.95	1.00	3.00
21	4.20	8.00	16.35	4.60	2.75	1.80	1.50	1.45	1.00	.90	.95	2.85
22	4.00	7.65	16.20	4.30	2.70	1.70	1.90	1.35	.95	.90	.95	2.75
23	3.90	8.00	15.90	4.75	2.70	1.70	3.20	1.30	1.00	.95	.95	3.00
24	3.90	8.10	15.70	5.65	2.65	1.60	4.70	1.30	1.00	1.20	.95	5.40
25	4.00	7.30	15.50	8.90	2.60	1.75	3.60	1.30	1.00	1.15	1.00	6.40
26	4.25	7.00	14.90	9.00	2.50	1.60	3.20	1.60	1.00	1.00	2.15	7.10
27	4.15	8.30	13.25	8.90	2.45	1.60	3.00	1.20	.95	1.00	2.90	7.00
28	4.00	11.00	11.00	8.30	2.35	1.65	3.60	1.10	.95	.95	3.00	6.60
29	3.90	.....	8.00	6.90	2.30	1.70	4.20	1.50	.90	.95	3.00	6.00
30	3.75	.....	7.90	5.45	2.20	1.65	5.20	2.10	.90	.90	2.75	4.85
31	3.70	.....	8.50	.....	2.70	.....	4.75	2.10	.....	.95	.....	4.00

COOSA RIVER AT LOCKS NOS. 4 AND 5, ALABAMA.

The station at Lock No. 4 is located 3 miles above Riverside, Alabama. Measurements here give the discharge past Riverside except the small quantity, about 1 cubic foot per second, flowing into the Coosa from Blue Spring Branch. The measurements are made from the bridge of the Southern Railway at Riverside. A record has been kept at Lock No. 4 by the United States Engineer Corps. The first section of the vertical gage rod is fastened to the lower end of the cofferdam, 500 feet below the dam on the river. The second section is fastened to a sycamore tree, 150 feet below rod. The zero of rod is 477.30 feet above the Mobile datum. The bench mark is a brass point in a stone post 1,000 feet up the river from lower gage, and is 510.5 feet above Mobile datum.

The station at Lock No. 5 is described in the Eighteenth Annual Report, Part IV, page 101, and is located one-half mile above the Birmingham and Atlantic Railroad crossing and about 20 miles below gaging station at Riverside, Alabama. The gage is vertical in two sections, fastened to the trees immediately above the landing of Collins Ferry. The zero of the gage is 460.37 feet above Mobile datum. Bench mark No. 1, which is on the tree to which one section of the rod is fastened, is 471.80 feet above Mobile datum. Bench mark No. 2 is

nter of iron plate at top of cylindrical pier, at right bank upstream le of the railroad bridge, and is at an elevation of 493.91 feet obile datum. Records of river height are kept by the United States ngineer Corps, and are kindly furnished to the Survey. Measureents of discharge are not made at either of these stations.

Daily gage height, in feet, of Coosa River, at Lock No. 4, Alabama, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.0	7.6	14.0	11.6	5.5	2.8	1.9	4.5	2.2	0.4	0.5	2.2
2	3.0	7.7	14.2	11.7	5.2	2.9	1.8	3.3	2.3	.4	.5	1.9
3	3.3	8.8	14.2	11.1	4.8	2.9	1.6	2.5	3.2	.5	.6	1.4
4	3.5	8.6	13.5	10.6	4.6	2.6	1.5	2.0	2.5	.5	.6	1.4
5	3.3	10.7	11.4	9.8	4.3	2.2	1.4	1.8	1.8	.5	.6	1.4
6	3.3	14.2	9.5	8.6	4.2	2.2	1.3	1.7	1.4	.5	.6	1.4
7	3.9	15.9	9.2	9.8	4.1	2.7	1.3	1.7	1.3	.5	.6	1.3
8	5.0	16.4	8.9	12.8	4.6	2.7	1.3	1.5	1.3	.5	.5	1.1
9	5.4	16.4	8.3	14.0	4.4	2.0	1.6	1.4	1.2	.8	.5	1.0
10	6.0	16.1	7.3	13.9	4.3	1.9	1.8	1.5	1.0	1.1	.5	1.0
11	6.4	15.8	6.5	13.2	4.0	1.9	1.7	1.5	.9	1.0	.5	1.0
12	6.6	15.5	6.1	11.6	4.0	1.9	1.5	1.6	1.0	1.0	.5	6.7
13	6.0	14.9	5.8	10.0	3.8	2.0	1.5	1.5	2.5	1.3	.5	9.4
14	5.8	13.9	8.5	8.1	3.8	2.0	1.4	1.4	2.8	.8	.5	9.8
15	5.5	10.6	9.4	7.1	3.3	2.7	1.3	1.3	1.8	.9	.5	7.4
16	5.1	7.5	19.7	6.6	3.3	3.7	1.3	1.4	1.3	.2	.6	5.8
17	5.4	7.8	20.2	6.2	3.3	2.7	1.1	1.2	1.0	.3	.6	4.3
18	5.8	8.6	19.1	5.9	3.0	2.2	1.1	1.5	.9	.3	.5	3.4
19	5.7	9.6	18.5	5.7	3.0	1.9	1.1	1.9	.8	.4	.4	2.8
20	5.4	9.6	18.8	5.4	3.0	2.0	1.1	1.7	.7	.4	.4	2.4
21	5.0	9.1	18.8	5.2	3.0	2.0	1.5	1.4	.7	.4	.8	2.6
22	4.6	8.8	18.7	5.1	2.8	1.8	1.6	1.2	.6	.4	.6	3.0
23	4.3	9.7	18.4	5.5	2.8	1.7	2.2	1.0	.4	.4	.7	3.0
24	4.3	9.3	18.0	6.8	2.7	1.7	5.6	.9	.3	.4	.8	5.9
25	4.8	8.6	17.5	10.6	2.9	1.7	5.5	1.0	.3	.2	.8	7.6
26	4.9	7.7	17.0	10.5	3.0	1.6	3.8	1.4	.4	.6	2.2	8.3
27	4.9	11.2	16.7	10.5	2.7	1.6	3.4	1.0	.4	.6	3.1	7.8
28	4.6	12.9	15.2	9.8	2.7	1.5	3.4	1.0	.4	.5	3.4	6.3
29	4.3	.....	12.7	8.0	2.7	1.8	4.1	1.5	.5	.6	3.1	5.4
30	4.0	.....	9.5	6.0	2.4	1.8	6.3	2.1	.4	.5	2.8	4.4
31	.....	.....	9.5	.....	3.0	.....	5.3	2.3	.....	.5	.....	3.8

Daily gage height, in feet, of Coosa River at Lock No. 5, Alabama, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.7	3.9	10.5	8.6	3.3	1.3	0.8	2.5	1.0	0.1	0.1	1.0
2	1.7	4.7	10.4	8.8	2.9	1.4	.7	1.7	1.1	.1	.1	.8
3	1.7	5.7	10.4	8.1	2.7	1.5	.6	1.2	1.1	.1	.1	.6
4	1.7	5.6	10.0	7.6	2.5	1.4	.6	.9	1.0	.1	.1	.5
5	1.7	7.1	8.9	7.4	2.3	1.2	.6	.7	.8	.1	.1	.5
6	1.6	10.1	6.7	6.7	2.2	1.0	.5	.7	.6	.1	.1	.5
7	1.9	12.1	6.4	7.6	2.1	.9	.4	.7	.5	.1	.1	.4
8	2.8	12.5	6.0	10.0	2.0	.9	.5	.6	.5	.1	.1	.4
9	3.0	12.4	5.4	11.0	2.3	.9	.5	.6	.4	.1	.1	.4
10	3.3	12.0	4.7	10.5	2.2	.8	.7	.6	.4	.2	.1	.4
11	4.1	11.6	4.0	9.7	2.0	.8	.7	.5	.3	.3	.1	.4
12	4.1	11.4	3.7	8.5	2.0	.9	.6	.5	.3	.3	.1	4.0
13	3.7	10.9	4.3	7.0	1.8	.9	.6	.5	.3	.4	.1	5.6
14	3.4	10.0	6.0	5.4	1.8	1.0	.5	.5	1.3	.4	.1	6.2
15	3.2	7.8	6.7	4.6	1.7	1.3	.5	.5	.8	.3	.1	5.4
16	3.0	4.8	14.8	4.0	1.7	1.8	.4	.8	.5	.2	.1	4.6
17	3.0	5.0	15.4	3.9	1.6	1.6	.4	.5	.3	.2	.1	2.4
18	3.3	5.6	14.5	3.6	1.5	1.3	.4	.5	.3	.1	.1	1.6
19	3.2	6.2	14.0	3.4	1.5	1.0	.4	.8	.2	.1	.1	1.3
20	3.0	6.4	14.1	3.2	1.5	.9	.3	.6	.2	.1	.1	1.2
21	2.8	6.0	14.0	3.1	1.5	.8	.5	.6	.1	.1	.1	1.2
22	2.5	5.8	14.0	3.0	1.4	.8	.8	.4	.1	.1	.1	1.3
23	2.3	6.4	14.0	3.0	1.3	.7	1.4	.4	.1	.1	.1	1.4
24	2.3	6.1	13.5	4.0	1.3	.7	2.9	.4	.1	.1	.1	2.4
25	2.6	5.6	13.0	7.1	1.3	.7	3.0	.4	.1	.1	.1	4.6
26	2.7	5.0	12.7	7.2	1.3	.6	2.1	.4	.1	.1	.8	5.3
27	2.7	9.5	12.4	7.2	1.3	.6	1.7	.4	.1	.1	1.5	4.9
28	2.5	9.6	11.0	6.6	1.1	.6	1.9	.3	.1	.1	1.7	3.8
29	2.3	.....	9.5	5.3	1.1	.7	2.6	.5	.1	.1	1.4	2.8
30	2.1	.....	7.1	4.0	1.0	.9	3.8	1.0	.1	.1	1.3	2.3
31	2.2	.....	6.9	.....	1.3	.....	3.1	1.0	.....	.1	.....	1.9

COOSA RIVER AT WETUMPKA, ALABAMA.

This station is located at gage No. 1, 3 miles above Wetumpka, Alabama, and was established November 5, 1889, by the United States Engineer Corps, who have maintained daily gage readings since that date until December 31, 1898, when the station was abandoned. The gage heights here are affected by backwater from Tallapoosa River at high stages of the latter stream, so that the record does not show the true flow of Coosa River. Discharge measurements can not be made at the Wetumpka bridge, as it is located directly over a shoal. Discharge measurements will be made next year at Montgomery, 10 miles below Wetumpka, but below the mouth of Tallapoosa River, and at Selma, 45 miles below Montgomery, at both of which points Weather Bureau stations are maintained.

TALLAPOOSA RIVER AT MILSTEAD, ALABAMA.

Tallapoosa River rises in the west-central part of Georgia and flows in a southwesterly direction into Alabama, where it joins the Coosa, to form Alabama River, 6 miles above Montgomery, Alabama. Its upper tributaries drain an area between the Chattahoochee and Coosa basins. At Tallassee, Alabama, it crosses the southern fall line. The shoals at this place have a fall of 60 feet, forming an obstruction to navigation. The drainage area is largely wooded, with cultivated fields at short intervals. A gaging station was established at Milstead on August 7, 1897, at the bridge of the Tallassee and Montgomery Railway, about one-fourth of a mile from Milstead, Alabama. The bridge is of iron, two spans of about 155 feet each, with short wooden trestles at each end. The initial point of measurement is the end of iron bridge, left bank, downstream side. The rod of wire gage is fastened to outside of guard rail on downstream side of bridge. The gage was last verified April 18, 1899. The bench mark is top of second cross beam from left-bank pier, downstream end, and is 60.00 feet above datum. The channel is straight at the bridge, and bends above and below. The current is sluggish at low water and obstructed by center pier of bridge. The banks are high, but overflow at extreme high water for several hundred feet on each side. The bed is fairly constant, and all water is confined to the main channel by railroad embankments. The observer is Seth Johnson, a farmer and fruit grower, Milstead, Alabama. Records of discharge measurements may be found as follows: 1897, Nineteenth Annual Report, Part IV, page 250; 1898, Twentieth Annual Report, Part IV, page 193.

The following measurements were made by Max Hall during 1899:

April 17, gage height, 6.34 feet; discharge, 7,444 second-feet.
April 18, gage height, 5.63 feet; discharge, 6,853 second-feet.
May 17, gage height, 2.80 feet; discharge, 3,000 second-feet.
June 26, gage height, 2.05 feet; discharge, 1,847 second-feet.
September 9, gage height, 1.36 feet; discharge, 1,016 second-feet.
November 8, gage height, 1.25 feet; discharge, 972 second-feet.
December 18, gage height, 2.66 feet; discharge, 2,844 second-feet.

Two measurements of Big Sandy Creek, a tributary of Tallapoosa River, were made September 11. The first, near the bridge 4 miles from Dadeville, Alabama, showed a discharge of 79 second-feet and the second, at a point a short distance above the bridge, showed a discharge of 74 second-feet.

Daily gage height, in feet, of Tallapoosa River at Milstead, Alabama, for 1899.

Day.	Jan.	Feb	Mar.	Apr.	May.	June	July.	Aug	Sept.	Oct.	Nov.	Dec.
1	5.00	17.00	27.00	18.00	4.30	2.40	2.80	3.00	2.40	0.70	1.50	2.40
2	4.60	11.60	19.00	12.20	4.00	2.90	2.30	2.70	2.30	.70	1.40	2.50
3	3.90	24.50	13.50	6.50	3.90	2.40	1.90	3.10	2.10	.80	1.40	2.60
4	3.90	29.00	9.60	6.40	3.80	2.40	1.80	3.10	2.00	.90	1.30	2.60
5	3.90	12.90	14.20	8.50	3.70	2.30	1.60	2.50	1.80	1.00	1.30	2.90
6	3.80	11.90	13.20	9.70	3.60	2.20	1.50	2.30	1.60	1.40	1.20	2.20
7	7.40	17.50	10.10	10.30	3.50	2.10	1.50	2.20	1.60	1.40	1.20	2.00
8	8.00	27.00	8.60	13.00	3.60	2.00	2.00	2.00	1.40	1.30	1.20	1.90
9	7.10	19.00	7.70	13.00	3.50	1.90	2.20	1.80	1.40	1.30	1.20	1.80
10	6.40	13.80	7.20	11.20	3.40	1.70	2.00	1.60	1.30	1.30	1.20	1.90
11	18.50	10.00	6.80	8.40	3.30	1.90	1.80	1.50	1.20	1.40	1.30	2.00
12	16.80	8.30	6.60	7.00	3.20	2.00	1.70	1.70	1.20	1.40	1.30	15.20
13	13.00	7.40	6.50	6.50	3.10	2.00	1.50	1.60	1.20	1.30	1.30	13.20
14	11.60	7.00	6.40	6.20	3.10	2.70	1.40	1.60	1.10	1.30	1.30	8.20
15	9.40	6.10	7.20	6.00	3.00	2.70	1.30	1.50	1.00	1.20	1.30	5.00
16	7.80	10.40	12.20	7.10	2.90	2.60	1.30	4.00	1.00	1.10	1.30	3.70
17	12.70	11.50	11.00	6.60	2.80	2.10	1.20	3.90	1.00	1.20	1.60	3.00
18	10.00	10.60	10.20	5.60	2.70	1.90	1.10	2.20	1.00	1.10	1.50	2.60
19	8.00	9.30	14.80	5.50	2.60	1.80	1.60	1.90	1.10	1.20	1.50	2.50
20	6.50	8.30	13.90	5.40	2.50	1.80	1.40	1.70	1.00	1.30	1.50	2.70
21	5.70	8.30	10.40	5.20	2.60	1.70	8.40	1.50	.90	1.40	1.40	2.70
22	5.30	8.40	8.30	5.00	2.70	1.50	16.75	1.60	1.00	1.50	1.40	2.70
23	5.10	7.60	8.10	4.90	2.60	1.50	14.00	2.00	1.00	1.60	1.60	2.60
24	5.20	6.90	12.70	6.00	3.30	1.50	16.95	2.60	.90	1.80	1.80	9.30
25	5.20	6.40	8.70	10.00	4.60	1.50	7.90	1.90	.90	1.50	2.20	9.40
26	5.10	6.30	7.80	7.50	3.30	2.00	6.70	1.80	.90	1.40	4.60	7.20
27	4.80	25.00	6.90	6.60	2.80	2.50	6.80	3.70	.90	1.30	6.20	5.00
28	4.70	37.00	6.80	5.80	2.60	2.50	8.40	2.80	.80	1.20	4.80	4.00
29	5.10	.....	9.00	4.90	2.50	2.20	10.10	2.10	.80	1.50	3.60	3.50
30	5.20	.....	8.90	4.60	2.60	2.70	5.40	1.90	.80	1.50	2.80	3.10
31	6.50	.....	13.85	.....	2.50	.....	4.40	2.30	.....	1.60	.....	2.90

ALABAMA RIVER AT MONTGOMERY, ALABAMA.

This river is formed by the junction of Coosa and Tallapoosa rivers 6 miles above Montgomery. The basin is described at length under the descriptions of its two tributaries. A gage rod was established by the United States Engineer Corps a number of years ago at the Montgomery wharf, near the Union Passenger Station, at foot of Commerce street. The readings are now taken by the Weather Bureau and are furnished to our Survey. The gage rod is in six sections, as follows: Section 1, from 2 to 10 feet on fender pile at face of

wharf, 108 feet from lower end; section 2, from 10 to 15 feet at upper end of pile protection to Louisville and Nashville Railroad bank in corner pile, and the 15-foot mark is 1.1 feet above the top of pile; section 3, 15 to 27 feet on bent in center of drain, on the lower side of Commerce-street sewer; section 4, 27 to 36 feet, on upper side of sewer, third bent; section 5, 36 to 46 feet, same side of sewer, sixth bent; section 6, 46 to 50 feet, same side of sewer, seventh bent. The rods are of pine timber, painted and graduated to feet and tenths. There are also two new sections, 15 to 25 feet and 25 to 37 feet, on trees about 50 yards south of the old gage. The bench mark is northeast corner of stone doorsill, north door of Windsor Hotel, on Commerce street, and is 57.68 feet above zero of gage. This latter datum is 103.7 feet above sea level. The high-water mark for Montgomery is 59.7 feet, and was reached in April, 1886. The danger line is placed at 35 feet. The width of the river at low water is 690 feet. No discharge measurements at this station were made during 1899, but will probably be made in the coming year, and in that case the measurements will be made at the iron bridge of the Louisville and Nashville Railroad, about 3 miles above Montgomery. This bridge is 60.6 feet above low water, with three spans over the river, the center one being a draw or turn span.

Daily gage height, in feet, of Alabama River at Montgomery, Alabama, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.0	13.0	35.1	20.3	9.8	3.2	2.3	9.4	3.1	−0.3	0.4	3.3
2	5.2	14.9	35.2	21.5	8.4	3.5	2.5	7.2	2.6	−.4	.2	2.8
3	5.1	19.0	33.5	21.4	7.3	3.7	2.3	6.8	2.2	−.4	.1	2.5
4	5.0	23.0	30.3	19.0	6.7	3.8	2.0	5.6	2.1	−.3	.0	2.3
5	4.8	23.5	27.0	17.2	6.3	3.6	1.7	4.8	2.5	.2	.0	2.0
6	4.8	22.1	25.6	16.8	6.0	3.2	1.5	3.8	1.9	.1	.0	1.7
7	5.3	24.8	18.7	16.4	5.8	3.0	1.2	3.4	1.7	.2	−.1	1.5
8	7.4	28.9	16.1	20.3	5.6	2.8	1.2	3.2	1.3	.3	−.1	1.4
9	8.5	31.6	14.3	22.3	5.8	2.6	1.3	2.9	.5	.3	−.1	1.3
10	8.9	32.0	13.2	24.2	6.3	2.5	1.5	2.5	.9	.2	−.1	1.0
11	11.0	31.6	12.1	24.0	6.3	2.4	1.7	2.2	.9	.2	−.1	7.5
12	17.5	29.7	10.9	22.1	5.7	2.3	1.7	2.0	.8	.4	−.1	14.6
13	18.0	26.8	9.8	19.4	5.1	2.4	1.5	1.7	.6	.6	−.1	15.0
14	16.3	24.7	13.2	17.1	5.1	2.6	1.3	1.5	.5	.4	−.1	15.5
15	13.9	20.6	16.0	14.1	5.0	2.8	1.1	1.4	1.3	.5	−.1	14.6
16	12.7	19.2	18.3	12.0	4.8	3.3	1.0	1.3	1.8	.4	−.1	11.4
17	12.4	17.6	24.9	10.4	4.4	3.4	.9	2.3	1.0	.2	.0	7.5
18	13.0	16.5	29.0	9.8	4.3	3.5	.9	3.5	.8	.1	.1	5.9
19	13.1	15.9	30.8	9.3	4.0	3.1	.9	2.8	.5	.1	.1	4.6
20	10.0	15.9	31.7	9.0	3.9	2.2	1.4	1.8	.4	.2	.1	4.0
21	8.4	16.0	32.0	8.5	3.8	1.7	1.8	1.8	.0	.4	.1	3.7
22	7.8	15.4	32.0	8.1	3.8	1.5	4.8	1.5	.0	.5	.0	3.6
23	7.8	14.7	31.4	8.2	3.8	1.2	9.0	1.5	−.1	.8	.4	3.5
24	8.9	13.5	30.0	9.4	4.9	1.2	13.7	1.8	−.1	.4	.5	9.6
25	8.9	13.5	30.0	11.0	5.2	1.2	16.0	2.0	−.1	.4	.6	10.5
26	9.0	13.5	28.3	14.8	5.2	1.6	11.7	1.5	−.1	.3	1.0	11.2
27	9.1	24.0	27.4	16.7	4.3	1.8	8.3	1.7	−.2	.2	3.0	12.0
28	9.0	33.0	26.1	16.7	3.8	2.1	9.5	2.7	−.2	.1	4.0	10.6
29	8.7	.....	24.9	15.8	3.5	2.3	10.4	2.8	−.3	.1	3.8	8.6
30	8.7	.....	23.9	12.2	3.1	2.1	10.4	1.9	−.3	.4	3.3	6.9
31	9.0	.....	19.3	.....	3.0	.....	9.2	1.9	.....	.4	.....	5.5
Mean	9.5	21.2	24.2	15.6	5.2	2.5	4.3	2.9	0.9	0.2	0.6	6.7

ALABAMA RIVER AT SELMA, ALABAMA.

ation is located 45 miles by railroad below Montgomery, and nally established by the United States Engineer Corps. Read- now taken by the Weather Bureau. The gage rod is a pine inted white with black marks, and is in two sections. Sec- feet to 23 feet, is fastened to the pile on the lower side of the n on the draw pier. Section 2, 23 feet to 48 feet, is spiked to ge. The bench mark is an iron bolt driven in the face of a ff, 182.3 feet from center of north face of pier and above the nd is 26.05 feet above zero of the gage. The high-water 57 feet, and was reached April 8, 1886. The danger line is t 35 feet. The rod is attached to the iron highway bridge, of which is about 60 feet above low water. There is a turn- one end. The section is good for measurements, with a width 300 feet at low water. No measurements of discharge were re during 1899.

gage height, in feet, of Alabama River at Selma, Alabama, for 1899.

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
6.2	10.8	35.8	23.8	13.9	4.5	2.5	11.1	3.7	—1.2	—0.2	4.8
6.2	17.0	36.8	24.3	11.5	4.0	2.5	9.9	4.3	—1.3	— .3	3.7
6.5	20.2	38.8	24.9	9.9	4.0	2.6	9.0	4.6	—1.3	— .5	3.0
6.2	24.0	37.7	24.1	9.8	4.0	2.6	6.7	4.8	—1.3	— .6	3.0
6.2	26.8	35.3	22.3	8.5	3.8	2.1	6.5	4.4	—1.1	— .7	2.8
5.8	27.2	32.6	20.9	8.1	3.9	1.6	5.8	4.4	—1.0	— .7	2.8
6.6	27.2	30.5	20.0	7.5	3.8	1.6	5.3	4.1	—1.6	— .8	1.7
8.3	29.8	27.5	19.8	7.4	3.7	1.5	4.7	3.9	— .5	— .8	1.7
9.7	32.2	23.4	23.3	7.3	3.3	1.4	4.5	3.6	— .4	— .8	1.3
11.6	33.9	19.7	25.6	7.3	3.1	1.3	3.7	.6	— .4	- .9	1.3
13.9	34.4	16.9	26.9	7.5	2.8	1.3	3.5	.4	- .5	— .9	1.4
14.8	33.9	15.0	26.6	7.2	2.3	1.2	3.0	.3	— .6	1.0	4.0
21.2	32.0	13.9	25.1	6.8	2.6	1.5	2.9	.3	— .6	1.1	10.4
21.9	30.0	16.2	22.6	6.5	2.4	1.2	2.7	.2	— .2	1.2	16.6
19.8	28.0	16.8	19.5	6.3	2.4	1.1	2.6	.2	— .2	- 1.2	17.8
18.0	26.5	19.4	16.3	6.2	2.3	1.0	2.6	.1	— .2	- 1.3	16.3
17.5	26.8	21.4	14.0	6.1	2.8	1.0	2.6	.6	— .3	- 1.3	13.4
17.2	24.0	27.7	13.0	5.6	3.4	.7	3.6	1.3	— .5	- 1.3	9.9
17.0	22.3	31.6	12.0	5.4	3.9	.6	4.1	1.0	— .7	- 1.2	8.4
15.8	19.9	33.5	11.2	5.0	3.9	.6	4.3	.9	— .6	— 1.0	3.8
14.2	19.9	34.7	10.5	4.8	3.1	1.0	3.6	.6	— .7	- 1.0	3.8
12.6	19.5	34.8	10.4	4.5	2.8	1.6	3.5	— .6	— .8	— .6	3.4
10.2	18.8	34.2	10.2	4.4	1.6	5.5	3.4	— .7	— .2	— .6	3.4
10.3	17.8	33.4	10.1	4.8	1.4	10.7	3.1	— .8	.0	- .3	3.8
9.4	17.3	31.1	12.4	5.0	1.4	14.8	3.6	—1.0	.0	.1	7.6
9.0	16.4	32.6	13.5	6.0	1.6	17.0	4.2	—1.0	— .5	.2	12.2
8.9	20.3	31.8	16.3	6.1	1.7	17.0	3.9	—1.0	— .5	.9	13.5
8.6	31.2	30.5	17.9	5.2	2.0	14.9	3.6	—1.0	— .6	3.2	13.7
8.6	.....	29.3	17.7	4.5	2.2	13.1	4.3	—1.1	— .6	4.6	12.3
9.0	.....	27.8	16.1	4.3	2.4	12.8	4.6	—1.1	— .6	4.8	11.4
9.6	.....	26.3	.....	4.2	.....	11.9	3.8	.....	— .4	.....	8.3
11.6	24.6	28.3	18.4	6.7	2.9	4.8	4.5	1.2	— .6	— .2	7.1

CATAWBA RIVER NEAR BIRMINGHAM, ALABAMA.

surement of this river, a tributary of Alabama River, was Mr. S. Hill Lea, civil engineer, in June, 1897, at a point 7 rtheast of Birmingham, Alabama. The stage of the river sidered to be that of average low water. The mean velocity rrent was found to be 2.56 feet per second, and the discharge nd-feet.

BLACK WARRIOR RIVER AT TUSCALOOSA, ALABAMA.

The Black Warrior River rises in the south-central part of Alabama and flows in a southwesterly direction into the Tombigbee, on the southern boundary of Greene County. Tombigbee River flows southward from the junction until it reaches Alabama River, with which it unites to form Mobile River. The drainage area is for the most part flat, open country, much of it being under cultivation. Above Tuscaloosa it is largely in a Carboniferous formation, containing pervious strata, porous shales, and limestone caves, through which considerable water is probably lost. A continuous record of gage height at Tuscaloosa since 1889 has been kept by the United States Engineer Corps. During 1895 and 1896 a number of discharge measurements were also made, from which a rating table was obtained, and since that time measurements of flow have been made regularly by the United State Geological Survey, and computations made of the discharge. This station is described in the Eighteenth Annual Report, Part IV, page 103, and is located about three-fourths of a mile from the business center of Tuscaloosa, Alabama. It is reached by passing down Bridge street to the river, thence down the east bank 1,800 feet to the gage, which consists of an inclined timber 2 by 6 inches, supported on posts and graduated by means of notches placed 1 foot apart vertically. There are two bench marks, one on a willow tree, 10 feet west of gage, and 97.84 feet above Mobile datum; the other on a small hackberry, 30 feet south of the upper end of the gage, and 139.36 feet above Mobile datum. The zero of gage is 87.30 feet above same datum. The discharge measurements are made from the highway bridge above the gage. The channel is straight and unobstructed. The current is sluggish at time of low water; the banks high and rocky and not subject to overflow. The observer is R. C. McCalla, jr., United States assistant engineer. Records of measurement may be found as follows: From 1889 to 1896, Eighteenth Annual Report, Part IV, page 108; 1897, Nineteenth Annual Report, Part IV, page 251; 1898, Twentieth Annual Report, Part IV, page 194. The following measurements were made by B. M. Hall and Prof. George S. Wilkins, of the University of Alabama, in 1899:

Measurements of Black Warrior River at Tuscaloosa, Alabama.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec. feet.*	1899.	*Feet.*	*Sec. feet.*
February 21	19.36	12,855	March 4	23.70	12,609
February 21	19.25	12,640	March 14	31.18	36,653
February 24	22.85	16,216	March 14	34.37	40,331
February 28	39.47	48,010	March 17	59.50	119,553
March 1	35.50	24,988	March 18	56.40	86,410
March 2	30.35	18,052	March 23	40.30	23,911

ıge height, in feet, of Black Warrior River at Tuscaloosa, Alabama, for 1899.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
..	4.40	26.10	37.70	30.30	7.90	2.00	0.10	6.50	1.20	−1.50	−1.03	4.83
..	4.50	29.50	32.00	29.20	7.00	1.50	.80	4.90	.70	−1.61	−1.02	3.50
..	4.60	27.00	27.70	24.80	6.30	1.20	.30	3.40	.62	−1.80	−1.03	2.77
..	4.70	29.00	24.10	22.00	5.80	1.00	−.70	2.70	.23	−1.79	− .99	2.03
..	4.70	45.50	21.00	23.20	5.30	1.00	−.10	2.00	− .02	−1.51	−1.00	1.50
..	11.20	50.60	20.80	22.60	4.80	.90	−.30	1.90	− .17	−1.48	−1.02	1.22
..	42.50	51.40	19.50	23.30	4.40	1.00	−.20	1.80	− .38	−1.46	−1.03	.98
..	49.30	51.70	16.90	33.90	4.40	.80	−.30	1.30	− .40	−1.34	−1.03	.88
..	46.60	48.60	14.40	34.00	7.60	.40	−.40	1.20	− .46	−1.30	1.03	.58
..	40.40	43.10	12.90	30.80	6.50	.40	− .40	1.10	− .68	.96	−1.01	.60
..	35.70	37.80	11.90	27.00	5.10	.50	−.40	2.00	− .73	.78	−1.01	2.20
..	31.90	32.80	11.30	23.60	4.30	.50	− .50	1.70	− .79	.72	.98	23.50
..	28.00	28.80	10.00	20.10	4.20	.50	.60	1.30	.71	− .70	− .96	39.53
.	25.00	25.70	28.80	17.20	4.30	.50	.60	.90	.73	.88	− .98	35.71
..	22.20	22.90	44.50	14.90	4.70	.50	−.70	.60	− .78	.94	.99	26.50
..	20.00	21.60	59.30	13.00	4.30	.70	−.70	.40	.83	−1.03	−1.00	20.63
..	19.60	19.90	60.30	11.60	3.70	.60	−.70	.30	− .86	−1.07	− .97	15.21
..	20.10	20.10	57.70	10.50	3.30	.40	.70	.30	.88	−1.12	− .97	10.83
..	18.60	20.80	52.40	9.80	2.80	.30	.70	.60	.90	1.16	− .95	8.02
..	16.10	20.60	49.30	9.60	2.70	.20	− .70	.60	.92	− 1.12	.95	8.09
..	14.00	19.60	46.80	9.50	3.70	.10	.60	.70	− .94	−1.10	− .92	9.63
..	12.20	18.50	41.60	8.70	3.80	.40	.50	1.50	.90	− .84	− .89	10.80
...	11.00	22.70	36.80	8.60	3.30	−.10	−.20	2.60	−1.03	.73	− .33	10.63
..	11.00	23.10	33.00	11.30	3.10	−.10	−.60	2.50	1.05	.71	− .17	22.01
...	20.30	20.90	29.50	13.60	2.70	−.60	4.90	2.00	−1.04	.88	.88	29.04
..	29.30	18.50	26.50	13.20	2.50	−.20	7.60	2.30	− 1.05	− .94	2.60	25.91
...	26.20	23.50	24.20	12.60	2.00	.20	7.40	2.10	1.04	−1.02	4.50	20.98
...	22.50	30.00	22.30	11.40	1.75	.20	7.00	1.90	1.18	.60	10.48	17.00
...	18.60	.....	21.10	10.00	1.50	.20	9.50	1.60	− 1.28	.73	9.49	15.80
..	15.70	.....	19.30	8.90	1.60	.10	9.30	1.50	−1.38	.96	6.67	14.62
..	14.80	.....	18.10	.....	2.50	.....	8.50	1.10	.....	−1.03	.....	12.51

United States Weather Bureau has maintained gage readings nopolis, Alabama, on Tombigbee River, at the mouth of the Warrior River. The distance to Mobile is 185 miles. The gage on the steamboat landing, and is 225 feet in length. From the ı of the rod to the top of the bluff the gage is constructed of 2 inch pine boards set edgewise in a trench cut in the bank and ly fastened, the upper edge faced with three-eighths by 2 inch raduated to feet and tenths. At the top of the bluff to a point above highest water the gage is marked by rows of copper ɔn a 6 by 8 inch post set firmly in the ground. The bench mark top of water table on the north side of the city jail at the west-d, and is 68.40 feet above zero of gage and 13.71 feet below top ɜk of Southern Railway at the freight depot. The highest was 66 feet, on April 18, 1874; the lowest, 3.9 feet, on October 30, 1875. The danger line is at 35 feet.

ALLEGHENY RIVER.

gheny River, which with the Monongahela forms the Ohio at urg, rises in northern Pennsylvania, flows northerly into the ɔf New York, then again turning southerly flows through west-ennsylvania. The headwaters have an elevation of about 2,250 nd adjoin those of Genesee River on the north and of the ehanna on the east. The total length from the source to the at Pittsburg is about 300 miles, 47 miles of which are in New State. The catchment basin on the upper waters attains the

height of from 2,600 to 2,800 feet above sea level. The principal facts concerning this river have been given in a report by Mr. George M. Lehman, assistant engineer, contained in House Document No. 72, Fifty-fifth Congress, third session. The total area of the watershed as measured from the map of the Pennsylvania geological survey, is 11,400 square miles. The principal tributaries making up this total with their area in square miles are as follows: Conewago Creek, including Chautauqua Lake watershed, 935; Tionesta Creek, 458; French Creek, 1,180; Clarion River, 1,175; Redbank Creek, 526; Mahoning Creek, 397; Kiskiminitas River, 1,846, and Allegheny River above mouth of French Creek, about 5,950. The average fall of the river below Oil City is 2.2 feet per mile, but there are several stretches where for several miles the fall reaches nearly 5 feet per mile. Between Oil City and Tarentum, a distance of 112.6 miles, there are 81 ripples, some of them at very low water having only 0.5 foot depth of water; the depths in quiet water are in many places from 10 to 20 feet. The distance between Oil City and Tarentum, the part of the river surveyed and reported upon in 1897 by the United States Engineer Corps, and where the river is quite winding, is 112.6 miles by river channel and 57 miles by air line. The distance by river channel from Pittsburg to Franklin is 126.4 miles and the railroad distance 124 miles. The following table, furnished by Mr. George M. Lehman, was made in connection with the survey of the river by the United States Engineer Corps in 1897. It shows the heights above low water of 1865 and 1898:

Height of Allegheny River above low water in 1865 and 1898.

Distance from Pittsburg.	Place.	Width between banks.	Flood—	
			1865.	1898.
Miles.		*Feet.*	*Feet.*	*Feet.*
134.0	Oil City	800	22.5	12.5
126.4	Franklin (French Creek)	1,050	23.2	12.0
110.0	Kennerdell	900	26.5	13.5
91.6	Emlenton	500	31.3	19.0
85.0	Parker (Clarion River)	1,000	26.0	16.2
80.5	Monterey	700	32.0	20.5
70.7	East Brady	700	33.0	23.5
65.0	Redbank Junction (Redbank Creek)	950	24.5	18.0
56.2	Mahoning (Mahoning Creek)	1,000	28.3	23.5
45.6	Kittanning	1,000	30.3	25.0
38.2	Logansport	750	28.0	28.0
28.7	Freeport (Kiskiminitas River)	850	32.0	28.5
21.6	Tarentum	1,500	28.5	24.0
0	Pittsburg	1,000	31.4	29.0

It is said that the highest flood occurred in 1832, when the water rose to a height of 36 feet at Pittsburg. The flood of 1865 is the highest known, at least for any great extent of river and for which it was possible to get fairly reliable information. The depths show that the rainfall was quite general over the watershed, particularly

above Oil City. There is a very gradual and slight increase toward Pittsburg. The flood of 1898 was high on the lower Allegheny; the records show heavy rainfall over the watersheds of tributaries south of Clarion River, and the depths indicate this. The width of river has strong influence in depths, as shown in list.

Other high floods than those mentioned above have occurred at Pittsburg, but they have not all come from Allegheny River. The flood of 1884 backed water for several miles up from the mouth of the Monongahela, the depth recorded being 34.5 feet above low water. The flood of 1889 rose to 31.3 feet, but at points above the vicinity of Pittsburg the heights ranged about halfway between those of the 1865 and 1898 floods. The high water of 1865 is locally known as the "oil flood," because of the fact that many hundred barrels of oil awaiting shipment by steamboat from the Oil City district were carried downstream.

Observations of the discharge of the Allegheny at Pittsburg at the time of the 1898 flood were made by Mr. George M. Lehman on the velocity of drift passing between the bridges. The current averaged 7.7 miles per hour, and the estimated discharge was 290,000 second-feet.

YOUGHIOGHENY RIVER AT FRIENDSVILLE, MARYLAND.

This river rises in Garrett County, Maryland, and flows in a northwesterly direction into Pennsylvania, where it empties into Monongahela River 15 miles above Pittsburg. Its source is on the western slope of the Allegheny Mountains, at an elevation of about 2,900 feet. The average fall of the stream for 19 miles above its mouth is about 2 feet per mile, but above this point it soon increases to an average fall of nearly 5 feet per mile. The bank height above low water ranges between 15 and 28 feet, and the average width between banks from the mouth to West Newton, Pennsylvania, is 546 feet. The following heights at various points in Pennsylvania of the high water of February, 1897, above low-water stage, was furnished by Mr. George M. Lehman: Whikett, 13 feet; Jacobs Creek, 10 feet; Smithton, 14 feet; Port Royal, 17 feet; Snyder, 16 feet; West Newton, 20 feet; Suterville, 22 feet; Buena Vista, 26.5 feet; Coulterville, 28.5 feet; Boston, 29 feet; McKeesport, 28.5 feet.

A measurement of Youghiogheny River was made October 13, 1892, with surface floats, at Ohio Pyle, Pennsylvania, by Mr. Kenneth Allen, in connection with an investigation of a water supply for the works of the H. C. Frick Coke Company. It was during a period of extreme drought, and the discharge was found to be 106 second-feet. The area of its watershed was approximately obtained from maps of uncertain accuracy, but was called 1,775 square miles.

The station at Friendsville, Maryland, was established by E. G. Paul August 17, 1898. Measurements are made from the iron high-

way bridge connecting the east and west portions of the village. The wire gage is 20 feet from zero to the end of the weight, and referred to a scale board 14 feet long, graduated to feet and tenths. The channel is straight for several hundred feet above and below the bridge. The bed is rocky and the banks high and not subject to overflow. The observer is J. H. Cuppet, a merchant residing within a short distance of the gage. The results of measurements for 1898 may be found in the Twentieth Annual Report, Part IV, page 199. The following measurements were made by E. G. Paul during 1899:

January 24, gage height, 5.40 feet; discharge, 959 second-feet.
January 25, gage height, 6.35 feet; discharge, 2,050 second-feet.
May 17, gage height, 5.97 feet; discharge, 1,697 second-feet.
June 30, gage height, 5.40 feet; discharge, 944 second-feet.

Daily gage height, in feet, of Youghiogheny River at Friendsville, Maryland, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.20	5.00	6.50	6.50	4.60	4.90	5.20	4.50	4.00	4.10	4.10	4.30
2	5.20	4.90	6.40	6.30	5.00	4.90	4.80	4.30	4.10	4.10	4.60	4.30
3	5.20	5.00	6.30	6.00	5.20	4.80	4.60	4.20	4.00	4.10	5.00	4.30
4	5.40	7.40	6.30	5.80	5.30	4.80	4.40	4.20	4.00	4.10	4.80	4.30
5	6.50	7.00	7.70	5.30	5.30	4.80	4.60	4.60	3.90	4.00	4.50	4.30
6	6.30	6.20	8.20	5.20	5.20	4.60	4.50	4.80	3.90	4.00	4.50	4.50
7	6.10	5.90	6.60	5.10	5.20	4.50	4.50	4.50	3.90	4.00	4.40	4.60
8	6.00	5.60	6.20	6.90	5.10	4.50	4.50	4.30	4.10	4.00	4.30	4.60
9	5.80	5.40	5.90	6.50	6.90	4.40	4.40	4.20	4.00	4.00	4.30	4.80
10	5.60	5.30	6.30	5.90	6.50	5.20	4.40	4.20	4.40	4.00	4.40	4.90
11	5.30	5.20	6.10	5.70	6.30	5.90	4.30	4.30	4.40	3.90	4.30	4.90
12	5.20	5.10	6.00	5.50	5.90	5.80	4.20	4.20	4.30	3.90	4.20	5.40
13	5.10	5.10	5.90	5.30	5.60	5.60	4.20	4.20	4.30	3.90	4.20	5.80
14	6.10	Frozen	5.70	5.20	5.60	5.60	4.30	4.20	4.20	3.90	4.20	5.50
15	8.00	do	5.60	5.10	5.50	5.70	4.40	4.10	4.10	3.90	4.20	5.30
16	7.10	do	5.60	5.10	5.60	6.50	4.60	4.10	4.10	3.90	4.10	5.10
17	6.80	do	5.70	5.00	5.70	6.20	4.60	4.10	4.00	3.90	4.10	5.10
18	6.50	do	5.70	5.00	8.00	5.40	4.90	4.00	4.00	3.90	4.10	5.20
19	6.20	5.10	5.70	5.00	9.50	5.00	4.70	4.00	4.10	3.90	4.30	5.40
20	5.80	5.20	5.70	4.90	7.20	4.80	4.50	4.00	4.10	3.90	4.40	5.40
21	5.50	5.40	6.00	4.90	6.90	4.80	4.40	4.00	4.30	3.90	4.60	5.30
22	5.40	6.80	6.00	4.80	6.50	4.70	4.30	4.00	4.20	3.90	4.70	5.30
23	5.30	7.20	6.30	4.70	6.10	4.60	4.20	4.00	4.20	3.90	4.60	5.30
24	5.30	6.40	6.30	4.70	5.60	4.50	4.20	4.00	4.10	3.90	4.60	5.20
25	6.40	5.90	6.00	4.70	5.30	5.30	4.40	4.00	4.00	3.90	4.60	5.20
26	6.00	6.20	5.80	4.60	5.10	5.10	4.20	4.00	4.00	3.90	4.40	5.20
27	5.70	7.90	5.60	4.60	4.90	5.20	4.20	4.00	4.10	3.90	4.40	5.10
28	5.50	7.20	6.60	4.70	4.90	5.20	4.20	4.00	4.10	4.00	4.40	5.10
29	5.30	.....	8.00	4.70	4.80	5.40	4.40	4.10	4.10	4.00	4.40	5.10
30	5.10	.....	7.30	4.60	4.90	5.60	4.30	4.10	4.10	4.00	4.30	5.10
31	5.10	.....	6.90	.....	4.90	.....	4.30	4.00	.....	.....	.....	5.10

CHEAT RIVER AT UNEVA, WEST VIRGINIA.

This river rises in the eastern part of West Virginia, and flows almost due north across the Pennsylvania boundary, entering Monongahela River 3 miles north of the State line. The drainage area is partly mapped on the St. George, Piedmont, Franklin, Beverly, Monterey, and Huntersville atlas sheets. As there is no bridge at a place convenient for making measurements, a cable of 600 feet span was stretched across the stream 6 miles northeast of Morgantown, at Uneva, West Virginia, and observations of heights begun on July 8,

.899. The gage is a post bolted to a rock and graduated to feet and enths. The initial point of soundings is on the right bank. The channel above and below the station is straight. The current is sluggish. The right bank is low and subject to overflow, but the left bank is high and rocky. The bed of the stream is rocky and constant. The observer is A. F. Blosser, a blacksmith at Uneva, West Virginia. On July 8, 1899, a measurement at this station was made by E. G. Paul, at a gage height of 2.60 feet, and gave a discharge of 1,148 second-feet. A measurement was made of this river during a period of extreme drought at Morris crossroads, Pennsylvania, 1 mile below the West Virginia State line, on October 6, 1892, by Mr. Kenneth Allen, and the discharge found to be 249 second-feet.

Daily gage height, in feet, of Cheat River at Uneva, West Virginia, for 1899.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.00	2.20	2.00	3.70	2.90	17	3.50	2.40	2.70	1.80	2.40	3.40
2	.....	2.80	2.00	2.00	4.00	2.80	18	3.40	2.30	2.30	1.80	2.40	3.20
3	.....	2.70	2.30	1.90	3.80	2.70	19	3.00	2.20	2.20	1.70	2.50	3.00
4	.....	2.50	2.20	1.90	3.50	2.70	20	2.80	2.10	2.00	1.70	3.40	4.80
5	.....	3.40	2.20	1.90	3.30	2.60	21	2.40	2.00	1.90	1.60	3.40	4.40
6	.....	3.30	2.20	1.90	3.10	2.60	22	2.40	2.00	1.90	1.60	3.20	4.10
7	.....	3.00	2.10	1.80	2.10	2.50	23	2.40	1.90	2.30	1.60	3.00	3.90
8	2.60	2.80	2.00	1.80	2.10	2.50	24	2.30	1.90	2.20	1.60	3.00	5.20
9	3.00	2.70	2.00	1.80	2.80	2.50	25	2.50	1.80	2.20	1.60	3.90	4.40
10	2.80	2.60	2.20	1.70	2.70	2.50	26	2.70	1.80	2.10	1.70	3.70	3.60
11	2.70	2.50	4.10	1.70	2.60	2.70	27	2.80	1.80	2.30	1.70	3.50	3.20
12	2.50	2.40	3.80	1.70	2.90	5.50	28	2.60	2.50	2.40	1.70	3.30	2.90
13	2.40	2.30	3.50	1.70	2.70	6.40	29	2.50	2.40	2.30	1.70	3.10	2.70
14	2.50	2.20	3.20	1.70	2.60	4.80	30	3.50	2.30	2.20	1.70	3.10	2.60
15	2.80	2.20	3.00	1.70	2.60	4.20	31	3.60	2.30	.....	1.70	.....	.....
16	2.80	2.30	2.80	1.70	2.50	3.80							

The United States Weather Bureau have maintained gage readings on Cheat River at Rowelsburg, West Virginia, 36 miles above its junction with the Monongahela. The river at this point is 270 feet wide. The drainage area above the station is reported to be 890 square miles. The gage rod is on the second pier of the Baltimore and Ohio Railroad bridge. The bench mark of the United States Coast and Geodetic Survey, situated on the center pillar, west end of the bridge, is 26.66 feet above zero of the gage. The highest water was 22 feet, on July 10, 1880; lowest, 0.9 foot, on October 15, 1895. The danger line is at 14 feet.

NEW RIVER AT RADFORD, VIRGINIA.

This river rises in Watauga, Ashe, and Alleghany counties, North Carolina, and flows in a northwesterly direction into West Virginia, where it meets the Gauley, near Kanawha Falls, to form the Great Kanawha. The drainage area is mapped on the Kanawha Falls, Nicholas, Hinton, Beverly, Monterey, Huntersville, Lewisburg, Raleigh, Christiansburg, Dublin, Pocahontas, Abingdon, Wytheville, Hillsville, Yadkinville, Wilkesboro, and Cranberry topographic sheets. The upper tributaries have a general northeasterly and southwesterly direction, draining the narrow valleys of the greater Appalachian

Valley in Virginia. The basin of New River is for the most part mountainous and wooded, forming one of the most beautiful and picturesque sections in the eastern part of the United States. The river itself is rapid and a part of it almost impassable, even for canoes. Systematic measurements of flow of New River are made at Radford, Montgomery County, Virginia, and at Fayette, West Virginia. The station at Radford is located at the highway bridge close to the Norfolk and Western Railway station. It was established by D. C. Humphreys August 1, 1898. The gage used was erected by the United States Weather Bureau. It consists of a vertical board graduated to feet and tenths, and is attached to the iron framework connecting the pair of iron concrete cylinders which form the first pier from the right bank. The bench mark is the bottom of the lowest horizontal brace connecting the two cylinders, the elevation being 3.88 feet above the zero of the gage. The discharge measurements are made from the upstream side of the bridge. The initial point of soundings is on the right bank of the river 40 feet from the first pier. The bottom is of solid rock and gravel and is smooth and regular. On the left bank there is a steep, rocky bluff. The right bank is low and subject to overflow for about 100 yards, but all the water must pass under the bridge, which is about 85 feet above low water. The observer is A. J. Killinger, bridge tender at Radford, Virginia. The following measurements were made by D. C. Humphreys during 1899:

June 29, gage height, 1.12 feet; discharge, 4,980 second-feet.
August 11, gage height, 0.20 foot; discharge, 2,172 second-feet.

Daily gage height, in feet, of New River at Radford, Virginia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.00	0.70	3.00	2.40	1.40	1.10	0.80	0.00	1.00	0.30	0.40	−0.30
2	1.10	.70	2.60	2.00	1.30	1.00	.40	.00	1.00	.20	1.00	−.30
3	1.00	1.70	2.00	1.90	1.30	.90	.40	.00	1.00	.00	.90	−.20
4	1.20	2.00	6.05	1.60	1.40	.80	.30	.00	1.10	.00	.60	−.30
5	1.50	3.90	10.50	2.00	1.30	.70	.30	.00	1.00	.00	.30	−.10
6	1.80	5.70	7.00	1.90	1.00	.60	.40	.00	.10	.00	.20	−.10
7	4.00	5.00	5.00	1.80	1.10	.40	.50	.00	.00	.00	.00	−.10
8	2.60	4.20	4.00	4.10	1.20	.40	.40	.00	.00	.20	.00	−.10
9	1.80	3.10	2.90	3.80	1.90	.30	.30	.00	.00	.10	.00	−.20
10	1.70	3.00	2.50	2.90	1.80	.30	.20	.00	.00	.00	.00	+.10
11	1.60	2.40	2.20	2.90	2.00	.40	.30	.00	.00	.00	.00	.20
12	1.20	2.00	2.00	1.90	1.90	1.00	.30	.00	.00	.00	.00	1.75
13	1.50	1.90	1.90	1.80	2.00	3.90	.40	.00	.00	.00	.00	4.20
14	1.40	1.30	1.70	1.70	2.10	2.60	.20	1.00	.00	.00	.00	2.90
15	1.50	.90	3.00	1.80	1.80	2.00	.10	.50	.00	.00	.00	1.00
16	1.60	1.20	6.10	1.60	1.70	1.70	.00	.40	.00	.00	.00	.90
17	1.70	3.50	3.70	1.50	1.30	1.10	.00	.20	.00	.00	.20	.80
18	1.20	3.20	2.90	1.40	1.10	.90	.00	.20	.00	.00	.00	.80
19	1.10	3.60	7.75	1.60	1.00	.80	.00	.10	1.00	.00	.00	.70
20	1.10	2.80	7.90	1.50	1.00	.90	.00	.20	1.60	.00	.00	.90
21	.90	3.00	4.00	1.40	.90	.70	.10	.30	1.00	.00	.00	1.00
22	.80	3.00	3.80	1.30	.80	.60	.10	.30	.90	.00	.00	.90
23	1.00	2.90	3.00	1.30	1.10	.50	.10	.20	.80	.00	.00	.60
24	1.00	2.00	2.80	1.10	1.50	.50	.00	.00	.60	.00	.00	.60
25	.90	1.90	2.60	1.00	1.40	.60	.00	.00	.50	.00	.00	.50
26	1.00	2.00	2.50	2.00	1.10	.90	.00	.00	.50	.00	.00	.40
27	1.00	4.60	2.00	2.50	.80	1.20	1.00	.00	.40	.00	.00	.30
28	.90	4.00	3.10	2.00	.80	1.00	.90	1.00	.30	.00	.00	.30
29	1.00	.....	3.00	1.80	.70	1.00	.80	1.10	.40	.00	−.20	.20
30	.80	.....	3.20	1.60	.80	.90	.50	1.00	.30	.10	−.30	.20
31	.80	.....	2.90	.....	.90	.....	.40	1.00	.....	.00	.....	.20

GREENBRIER RIVER AT ALDERSON, WEST VIRGINIA.

This river rises on the western slope of the Allegheny Mountains, n Pocahontas County, West Virginia, and flows in a southwesterly irection, emptying into New River near Hinton, Summers County, Vest Virginia. The station was established by C. C. Babb and). C. Humphreys, at Alderson, West Virginia, 21 miles above Hinon, August 1, 1895. The drainage area at this point is 1,344 square niles, and is mapped on Hinton, Beverly, Monterey, Huntersville, nd Lewisburg atlas sheets. Greenbrier River receives many short ributaries from the Allegheny Range, and flows for the most part hrough a hilly, broken, and mountainous country well covered with orests. The station, described in the Eighteenth Annual Report, Part IV, page 111, is located one-half mile above the mouth of Muddy Creek, on the county bridge at Alderson. The wire gage, length 28.37 feet, is in the third panel of the second span, downstream side, and was last verified on August 12, 1899. This gage is referred to three bench marks: The first, on the upper end of the coping of the first pier from the left bank, 21.75 feet above zero of the gage; the second, on upper end of the bridge seat of the left bank abutment, 21.61 feet above the zero of the gage; the third, on stone foundation of water tank of the Chesapeake and Ohio Railway, 23.48 feet above the zero of the gage. A temporary bench mark has been established on lower end of third floor beam, in second span from left bank. Elevation 22.47 feet above the zero of the gage. The bridge consists of four spans 435 feet long. At ordinary stages the water flows in two channels, there being an island 600 feet long and 75 feet wide between them. The banks are high and not subject to overflow. The bed is of rock and gravel and fairly constant. The observer is W. J. Hancock, clerk in a hardware store, Alderson, West Virginia. Records of measurement can be found as follows: 1895–96, Eigtheenth Annual Report, Part IV, page 113; 1897, Nineteenth Annual Report, Part IV, page 254; 1898, Twentieth Annual Report, Part IV, page 204. The following measurements were made by D. C. Humphreys during 1899:

June 22, gage height, 1.94 feet; discharge, 456 second-feet.
August 12, gage height, 1.36 feet; discharge, 104 second-feet.

Daily gage height, in feet, of Greenbrier River at Alderson, West Virginia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	2.65	5.75	4.13	2.42	2.75	1.78	1.48	1.30	1.48	1.37	1.32
2	2.75	2.90	4.95	3.68	2.40	3.15	1.75	1.43	1.40	1.42	1.48	1.50
3	3.08	2.38	6.10	3.35	2.77	3.20	1.73	1.45	1.38	1.42	1.58	1.45
4	2.75	2.27	12.98	3.13	2.60	2.90	1.72	1.33	1.35	1.42	1.58	1.45
5	3.32	4.58	15.38	2.90	2.55	2.65	1.67	1.48	1.45	1.40	1.60	1.45
6	5.35	6.21	10.95	2.83	2.32	2.47	1.61	1.35	1.42	1.40	1.68	1.45
7	8.60	5.80	6.45	2.75	2.60	2.34	1.58	1.22	1.37	1.40	1.62	1.45
8	6.00	4.50	4.90	3.00	5.38	2.25	1.61	1.35	1.47	1.40	1.58	1.42
9	4.60	3.68	4.15	4.75	7.30	2.47	1.63	1.35	1.55	1.33	1.53	1.40
10	3.90	3.10	3.90	4.70	6.30	2.27	1.62	1.34	1.47	1.38	1.48	1.40
11	3.50	2.70	3.75	3.58	4.60	2.25	1.64	1.34	1.50	1.35	1.48	1.40
12	3.20	2.65	3.75	3.42	4.30	2.68	1.60	1.36	1.50	1.34	1.48	1.48
13	3.03	2.75	3.90	3.23	4.58	3.30	1.58	1.38	1.47	1.34	1.45	2.20
14	2.98	2.75	3.43	3.15	4.80	2.90	1.60	1.32	1.42	1.37	1.43	2.40
15	3.00	2.80	3.60	3.05	4.35	2.83	1.58	2.30	1.38	1.36	1.43	2.45
16	3.28	2.70	4.05	2.95	3.83	2.75	1.56	2.00	1.40	1.35	1.43	2.20
17	3.95	2.60	4.10	2.85	3.45	2.52	1.52	1.72	1.38	1.35	1.40	2.00
18	3.70	2.68	3.75	2.80	3.15	2.37	1.52	1.60	1.32	1.26	1.40	1.75
19	3.48	2.80	5.05	2.75	3.05	2.23	1.55	1.38	1.40	1.26	1.38	1.73
20	3.23	3.10	6.35	2.70	2.92	2.20	1.58	1.40	1.47	1.30	1.38	1.78
21	3.00	4.40	4.95	2.60	2.88	2.15	1.55	1.35	1.48	1.30	1.42	1.85
22	2.92	6.75	4.20	2.50	2.68	2.04	1.65	1.42	1.42	1.27	1.38	1.75
23	2.90	6.60	3.85	2.45	2.58	1.89	1.60	1.36	1.65	1.22	1.38	1.73
24	2.80	5.25	3.70	2.40	2.52	2.10	1.54	1.37	1.70	1.22	1.38	1.78
25	2.85	4.28	3.50	2.37	2.42	1.95	1.55	1.30	1.60	1.28	1.40	1.73
26	3.30	3.80	3.35	2.60	2.33	1.92	1.50	1.30	1.58	1.25	1.40	2.13
27	3.15	8.63	3.22	2.88	2.27	1.87	1.54	1.28	1.55	1.25	1.36	2.02
28	3.05	7.60	3.17	2.72	2.20	1.90	1.50	1.25	1.53	1.25	1.40	1.80
29	2.97	.....	6.38	2.57	2.17	1.92	1.58	1.37	1.50	1.25	1.53	1.80
30	2.70	.....	5.95	2.50	2.15	1.85	1.52	1.32	1.50	1.22	1.56	1.80
31	2.75	.....	4.65	.....	2.30	.....	1.50	1.32	.....	1.32	.....	1.95

The United States Weather Bureau has maintained gage readings on New River at Hinton, West Virginia. The drainage area above the station is reported to be 6,020 square miles. The railroad track at the depot is 33.5 feet above zero of gage. The highest water was on September 13, 1878, when it reached 23 feet; lowest, 0.5 foot, date unknown. The danger line is at 14.5 feet.

NEW RIVER AT FAYETTE, WEST VIRGINIA.

This station, established by C. C. Babb and D. C. Humphreys July 29, 1895, is described in the Eighteenth Annual Report, Part IV, page 113, and is located just below the mouth of Wolf Creek, on the highway bridge of one span at Fayette, West Virginia. The drainage area is mapped on the Kanawha Falls, Nicholas, Hinton, Beverly, Monterey, Huntersville, Lewisburg, Raleigh, Christiansburg, Dublin, Pocahontas, Abingdon, Wytheville, Hillsville, Yadkinville, Wilkesboro, and Cranberry atlas sheets. The wire gage is on the guard rail on the upper side of the bridge, about the middle of the span, the scale being graduated to feet and tenths. The gage is referred to four bench marks: First, the top of the bottom plate of the lower plate girder at the end of the first panel from the left bank, downstream side, 55.13 feet above the zero of the gage; second, top of lower end of coping on the main pier, right bank, downstream side, 52.13 feet above the zero of the gage; third, bridge seat on the right bank, downstream side, 54.58 feet above the zero of the gage; fourth, west

ner of abutment stone by Chesapeake and Ohio Railway station, 62 feet above the zero of the gage. The gage was last verified gust 14, 1899. The channel is straight above and below the sta- n, the current is swift and without obstructions, except for immense wlders in the bottom. The banks are high, rocky, and not sub- t to overflow. The bed is constant in section. The observer is W. Brellahan, agent Chesapeake and Ohio Railway, Fayette, West rginia. Records of measurement may be found as follows: 1895–96, ghteenth Annual Report, Part IV, page 115; 1897, Nineteenth nual Report, Part IV, page 156; 1898, Twentieth Annual Report, rt IV, page 203. The following measurements were made by D. C. mphreys during 1899: June 22, gage height, 3.65 feet; discharge, 97 second-feet; August 14, gage height, 1.80 feet; discharge, 2,985 ond-feet.

Daily gage height, in feet, of New River at Fayette, West Virginia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.45	4.45	9.00	8.40	6.80	6.30	3.80	2.40	2.70	0.95	1.80	0.80
2	4.30	5.00	11.51	8.35	6.25	6.35	3.00	2.30	1.55	.80	2.00	.85
3	4.10	6.40	19.35	6.50	6.00	6.00	3.20	2.20	1.50	.80	1.95	.80
4	4.10	7.25	35.08	6.10	5.85	5.50	3.05	2.40	1.90	.70	1.85	.70
5	4.00	14.20	29.78	5.50	5.70	4.95	2.40	2.25	2.20	.60	1.80	.55
6	5.90	20.60	24.43	5.85	5.75	4.60	2.45	2.15	2.10	.65	1.75	.50
7	13.00	22.80	18.78	7.50	5.65	3.15	2.25	2.00	2.00	.50	1.75	.50
8	10.10	17.10	14.00	8.10	7.55	3.25	2.20	1.85	1.40	.50	2.40	.45
9	6.50	14.35	13.30	7.10	12.40	3.20	2.10	1.40	1.30	2.05	1.65	.35
10	5.20	10.05	10.10	7.05	12.10	3.05	2.05	1.45	1.35	2.40	1.40	.80
11	8.10	8.30	9.50	7.15	8.10	3.05	1.95	1.35	1.45	2.35	1.20	1.00
12	7.50	6.50	9.00	9.80	9.95	3.00	1.90	1.30	1.40	2.65	1.20	1.00
13	7.40	6.10	8.20	8.00	8.25	6.85	2.05	1.35	1.30	2.60	1.15	1.70
14	6.45	5.30	8.00	7.55	8.90	11.60	1.85	1.40	1.30	2.60	1.10	9.50
15	6.15	4.50	8.40	7.00	10.70	11.75	1.45	1.50	1.25	2.45	1.10	8.30
16	5.80	4.30	8.25	6.75	9.50	10.30	1.35	2.10	1.20	2.40	1.05	4.60
17	5.50	4.45	10.50	6.65	8.00	7.05	1.30	2.70	1.15	2.30	1.05	3.25
18	5.05	6.50	10.10	6.00	6.60	6.00	1.40	2.15	1.20	2.15	1.00	2.95
19	4.75	6.85	15.00	5.55	5.95	5.30	1.35	1.45	1.20	2.10	1.00	2.80
20	4.35	6.20	20.00	5.55	5.65	5.05	1.40	1.40	1.15	2.10	1.00	2.85
21	4.10	9.40	17.60	5.50	5.20	4.35	1.80	1.30	1.10	2.05	.90	3.05
22	4.20	11.25	11.40	5.40	5.05	4.10	1.90	1.25	1.15	2.05	.90	3.10
23	5.55	10.10	8.30	5.40	5.00	3.50	1.75	1.25	1.10	2.00	.90	3.15
24	5.40	9.50	8.00	5.30	4.85	3.20	1.50	1.10	1.05	1.85	.95	3.00
25	4.90	8.60	7.55	5.25	4.60	3.20	1.45	1.05	1.15	1.80	1.00	3.40
26	4.85	8.95	6.40	5.40	4.50	3.10	1.45	.95	1.30	1.70	1.10	3.80
27	4.85	20.05	11.10	8.50	4.10	3.05	1.40	.90	1.20	1.70	1.10	4.10
28	4.60	14.65	15.00	8.70	3.90	3.30	1.30	.90	1.20	1.60	1.05	4.40
29	4.50	.....	18.70	7.75	3.85	4.15	3.80	.85	1.20	1.65	1.00	3.05
30	4.60	.....	14.10	7.10	3.80	4.05	3.00	.80	1.20	1.70	.85	2.90
31	4.50	.....	9.05	.....	4.30	.....	2.25	2.60	.....	1.60	.....	2.85

FRENCH BROAD RIVER AT ASHEVILLE, NORTH CAROLINA.

French Broad River rises in the western part of North Carolina, id flows in a general northwesterly direction into Tennessee. It ins Holston River just above Knoxville to form the Tennessee. ie watershed is for the most part mountainous and covered with a avy growth of timber. There are water powers capable of devel- ment at a number of places on the French Broad. The drainage ea is mapped on the Asheville, Mount Mitchell, Pisgah, and Saluda las sheets. Measurements of flow have been made at Asheville, orth Carolina. This station, described in the Eighteenth Annual

Report, Part IV, page 116, was established by Cyrus C. Babb in September, 1895, and is located at the Bingham School iron highway bridge, 3 miles west of Asheville, North Carolina, and is reached by an electric car line from Asheville. The Swannanoa River joins the French Broad 3 miles above the station. The zero of the rod of the wire gage is opposite the east edge of the fifth upright, first span from east, upper side. When the gage height is 3.22 feet, water surface is 17.18 feet below top of the lower end of the second floor beam, first span from the east. The gage was last verified on October 27, 1899. The initial point for soundings is on the right bank at the end of the first span of the bridge. Both banks may overflow in very high water. The current is swift, the channel straight, rocky, and reasonably permanent. The observer is J. M. Taylor, a carpenter at Asheville, North Carolina. Records of measurements may be found as follows: 1895–97, Nineteenth Annual Report, Part IV, page 257; 1898, Twentieth Annual Report, Part IV, page 205.

The following measurements were made by E. W. Myers and R. E. Shuford during 1899:

February 25, gage height, 4.30 feet; discharge, 2,810 second-feet.
June 16, gage height, 3.03 feet; discharge, 2,359 second-feet.
September 30, gage height, 1.94 feet; discharge, 714 second-feet.
October 27, gage height, 1.95 feet; discharge, 815 second-feet.
November 30, gage height, 2.12 feet; discharge, 1,043 second-feet.

Daily gage height, in feet, of French Broad River at Asheville, North Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.60	3.60	6.80	5.25	4.20	2.90	2.40	2.45	3.10	1.80	2.30	2.23
2	4.20	3.55	6.40	5.20	4.15	2.80	2.43	2.30	3.05	1.83	2.30	2.15
3	3.90	4.65	5.60	5.80	4.17	2.73	2.50	2.23	3.00	1.85	2.20	2.15
4	3.80	8.20	4.40	5.50	4.15	2.70	2.45	2.20	2.80	1.90	2.15	2.20
5	3.90	8.00	4.20	5.10	4.20	2.73	2.45	2.10	2.60	1.90	2.13	2.17
6	3.95	7.03	4.30	5.40	4.30	2.65	2.47	2.00	2.30	2.00	2.10	2.15
7	4.20	7.00	4.35	5.85	4.40	2.53	2.45	2.03	2.10	2.05	2.07	2.13
8	4.70	6.50	4.35	5.80	4.30	2.50	2.40	2.50	3.50	2.65	2.05	2.11
9	4.65	5.50	4.30	5.70	4.30	2.57	2.40	2.70	2.60	2.40	2.03	2.05
10	4.50	5.00	4.25	5.80	4.20	2.63	2.37	3.00	2.50	2.30	2.00	2.15
11	4.40	4.80	4.30	5.90	4.35	2.70	2.35	3.50	2.35	2.25	2.00	3.40
12	4.20	4.70	4.30	6.45	4.60	2.73	2.35	2.45	2.20	2.20	2.20	6.35
13	4.10	4.50	5.00	6.45	4.55	2.65	2.30	2.20	2.15	2.13	1.97	6.13
14	4.03	4.40	8.50	5.60	4.40	2.53	2.23	2.25	2.10	2.05	1.95	5.20
15	4.40	4.30	11.50	4.50	4.30	2.50	2.20	2.27	2.10	2.05	1.93	3.70
16	4.40	5.60	9.00	4.80	4.20	2.57	2.15	2.23	2.10	2.40	1.95	2.77
17	4.35	5.40	7.60	4.60	4.00	2.63	2.40	2.10	2.10	2.30	2.00	2.85
18	4.30	5.25	5.50	4.50	3.80	2.83	2.45	2.05	2.15	2.25	2.00	2.75
19	4.25	5.20	11.25	4.45	3.70	2.80	2.37	2.03	2.23	2.20	2.13	2.70
20	4.10	5.00	10.00	4.35	3.60	2.80	2.27	2.03	2.20	2.10	2.10	2.67
21	3.70	4.15	7.50	4.30	4.40	2.70	2.23	2.00	2.10	2.05	2.07	2.60
22	3.65	4.30	6.70	4.20	4.30	2.65	2.15	2.00	1.90	2.07	2.05	2.55
23	3.60	4.50	6.05	4.40	4.20	2.60	2.20	1.97	1.85	2.10	2.03	3.40
24	3.70	4.40	5.70	4.50	4.00	2.55	2.20	1.95	1.83	2.10	2.00	3.03
25	4.05	4.30	5.40	4.60	3.80	2.47	2.15	1.93	1.90	2.07	2.00	3.80
26	4.03	4.40	5.25	4.70	3.70	2.65	3.00	2.00	2.15	2.05	2.15	3.53
27	4.00	8.80	5.60	4.50	3.60	2.85	3.15	2.10	2.10	2.03	2.30	2.10
28	3.80	7.75	5.25	4.40	2.85	2.95	3.00	2.50	2.15	2.00	2.40	2.70
29	3.75	.....	5.33	4.30	2.80	2.80	2.80	2.60	1.85	2.05	2.37	2.65
30	3.70	.....	5.40	4.25	2.75	2.50	2.50	2.80	1.80	2.13	2.35	2.60
31	3.65	.....	5.35	.....	3.00	.....	2.43	3.85	.....	2.25	.....	2.57

TUCKASEGEE RIVER AT BRYSON, NORTH CAROLINA.

This river rises in the southwestern part of North Carolina, at the ase of Tennessee Ridge, which separates Jackson and Transylvania ounties. It flows in a northwesterly direction, emptying into the Little ennessee River at Bushnell, North Carolina. Measurements of disharge are made at Bryson, 2 miles below the mouth of Newton Mill reek. The drainage area is 600 square miles, largely of a rough and ountainous nature, covered with forest growth, and is mapped on ne Cowee, Pisgah, and Mount Guyot atlas sheets. The old station, escribed in the Eighteenth Annual Report, Part IV, page 116, was ocated on the Southern Railway bridge about 3 miles above Bryson, Iorth Carolina, and just below Governor Island post-office, and was bandoned March 25, 1897, because the section was poor. A new station was established by A. P. Davis November 7, 1897, at the highway bridge in the town of Bryson, North Carolina. The gage is bolted to the north pier, lower side, and can be read from the bridge. The initial point of sounding is at the south end of upstream hand rail. The channel is straight, but obstructed by the remnants of two old piers. The current is sluggish, the river bed muddy and fairly constant. The observer is H. H. Welch, a carpenter at Bryson, North Carolina. Results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 117; 1897, Nineteenth Annual Report, Part IV, page 257; 1898, Twentieth Annual Report, Part IV, page 206. The following measurements were made by E. W. Myers and R. E. Shuford in 1899:

Measurements of Tuckasegee River at Bryson, North Carolina.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
Feb. 25	7.00	19,160	Oct. 28	1.10	404
June 17	2.00	1,216	Do	1.10	460
June 19	1.80	712	Dec. 5	1.20	479
Sept. 20	1.25	376	Dec. 28	1.70	1,010
Do	1.25	399			

Daily gage height, in feet, of Tuckasegee River at Bryson, North Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.50	2.05	2.20	2.40	2.30	1.40	1.50	1.40	1.40	1.00	1.00	1.50
2	2.25	1.95	2.00	2.05	2.30	1.40	1.50	1.40	1.40	1.00	1.00	1.40
3	2.05	1.80	2.25	2.50	2.50	2.00	1.50	1.40	1.35	1.00	1.80	1.40
4	2.25	8.00	2.30	2.25	2.00	1.70	1.50	1.40	1.30	1.00	1.75	1.20
5	2.40	------	2.20	2.10	2.00	1.70	1.50	1.40	1.30	1.00	1.20	1.20
6	2.40	7.50	2.40	2.10	2.00	1.70	1.00	1.30	1.30	1.00	1.15	1.20
7	2.40	7.00	2.25	2.10	2.00	1.70	1.00	1.30	1.20	1.00	1.05	1.20
8	2.35	6.30	2.00	2.00	2.00	1.70	1.70	1.30	1.20	2.00	1.05	1.20
9	2.30	5.20	2.05	2.00	2.05	1.70	1.60	1.30	1.20	1.50	1.00	1.50
10	2.40	3.00	2.05	2.20	2.00	1.60	1.00	1.40	1.25	1.40	1.00	1.30
11	2.30	2.25	2.40	2.00	2.00	1.60	1.50	1.40	1.20	1.40	1.00	1.50
12	(a)	2.00	2.05	2.00	2.35	2.50	1.40	1.40	1.20	1.30	1.00	6.50
13	(a)	2.00	2.00	2.00	2.20	2.00	1.30	1.40	1.20	1.25	1.00	2.90
14	2.40	2.00	2.40	2.00	2.25	2.25	1.30	1.40	1.20	1.10	1.00	2.00
15	2.30	2.70	8.00	2.05	2.20	2.10	1.30	1.30	1.20	1.00	1.00	1.65
16	2.25	2.70	6.50	2.00	2.25	2.00	1.30	1.30	1.20	1.00	1.00	1.50
17	2.25	2.70	4.00	2.00	2.20	2.00	1.50	1.30	1.15	1.00	1.00	1.30
18	2.20	2.60	4.00	2.00	2.25	2.00	1.30	1.30	1.15	1.00	1.00	1.30
19	2.20	2.50	11.00	2.05	2.25	1.90	1.30	1.30	1.10	1.00	1.00	1.90
20	2.10	2.50	5.00	2.50	2.20	1.70	1.30	1.20	1.25	2.00	1.05	1.50
21	2.05	2.50	4.00	2.50	2.10	1.70	1.40	1.20	1.05	1.15	1.50	1.50
22	2.00	2.45	4.00	2.45	2.00	1.60	1.40	1.20	1.00	1.10	1.50	1.50
23	2.00	2.40	4.30	2.40	2.00	1.60	1.50	1.20	1.00	1.10	1.30	1.50
24	2.20	2.35	3.70	2.00	2.00	1.60	1.50	1.20	1.00	1.10	1.20	1.90
25	2.05	2.30	3.00	2.50	2.00	1.50	1.50	1.20	1.00	1.10	1.20	1.90
26	2.00	2.40	2.60	2.00	1.90	1.40	1.50	1.20	1.00	1.10	1.20	1.90
27	2.00	2.00	4.00	2.00	1.90	1.70	1.50	1.20	1.00	1.05	1.20	1.80
28	1.95	2.50	3.60	2.00	1.90	1.60	2.00	1.30	1.00	1.05	1.50	1.70
29	1.90	------	3.50	2.50	1.80	1.60	2.00	1.35	1.00	1.05	1.45	1.70
30	1.80	------	3.40	2.40	1.80	1.60	1.60	1.50	1.00	1.00	1.30	1.50
31	2.00	------	4.00	------	1.80	------	1.50	1.50	------	1.00	------	1.50

a River frozen.

LITTLE TENNESSEE RIVER AT JUDSON, NORTH CAROLINA.

This river rises in the mountains between North Carolina and Georgia, and flows in a northwesterly direction, emptying into Tennessee River at Lenoir, Tennessee. Measurements of flow are made at Judson, North Carolina, below the mouth of Sawyer Branch. The area drained is 682 square miles, which is largely mountainous and covered with a forest growth. It is mapped on the Nantahala, Cowee, and Walhalla atlas sheets. The station, as described in the Eighteenth Annual Report, Part IV, page 117, was established by E. W. Myers in June, 1896. It is located on the Southern Railway bridge about one-fourth of a mile from Judson, North Carolina. The river is straight for several hundred yards above and below the station; the bottom rocky and very rough on the west side and sandy on the east side. The current is swift and considerably obstructed by two old piers. The section is constant, but not a good one for measurements. The observer is R. C. Sawyer, a farmer at Judson, North Carolina. Records of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 117; 1897, Nineteenth Annual Report, Part IV, page 256; 1898, Twentieth Annual Report, Part IV, page 207. The following measurements were made by E. W. Myers and R. E. Shuford during 1899:

February 27, gage height, 10.25 feet; discharge, 21,880 second-feet.
June 20, gage height, 3.30 feet; discharge, 1,491 second-feet.
September 21, gage height, 2.23 feet; discharge, 339 second-feet.
September 27, gage height, 2.65 feet; discharge, 721 second-feet.
October 29, gage height, 2.84 feet; discharge, 896 second-feet.
December 6, gage height, 2.75 feet; discharge, 758 second-feet.

age height, in feet, of Little Tennessee River at Judson, North Carolina, for 1899.

.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
...	3.52	3.56	4.82	4.78	3.78	2.38	3.14	3.70	4.32	2.48	2.48	2.72
...	3.59	3.59	4.39	4.50	3.76	2.47	3.40	3.68	4.21	2.46	2.49	2.72
...	3.59	4.98	3.98	3.99	3.80	2.40	3.33	3.68	3.17	2.46	2.40	2.70
...	3.57	11.38	3.74	3.82	3.92	2.37	3.30	3.64	3.80	2.45	2.41	2.70
...	3.58	10.56	3.72	3.81	5.68	2.38	3.27	3.62	3.81	2.42	2.72	2.70
...	3.52	9.72	3.64	3.80	4.93	2.34	3.28	3.58	3.70	2.39	2.74	2.58
...	4.23	11.40	3.64	3.78	4.80	2.31	4.42	3.47	2.91	2.39	2.69	2.59
...	4.23	9.58	3.68	3.72	3.91	2.30	3.90	3.28	2.46	3.71	2.68	2.52
...	3.98	8.56	3.67	3.72	3.90	2.29	3.18	2.71	2.33	5.58	2.64	2.50
...	3.92	7.51	3.61	3.70	3.82	2.29	3.10	2.70	2.32	4.31	2.64	2.62
...	3.84	5.32	3.61	3.68	3.71	2.27	2.90	4.98	2.32	3.72	2.63	2.62
...	3.84	5.32	3.62	3.69	3.70	2.91	2.71	4.57	2.28	3.20	2.62	2.60
...	3.80	4.58	3.64	3.49	3.68	6.71	2.71	3.38	2.27	2.58	2.62	2.70
...	3.71	3.72	9.55	3.48	3.60	6.70	2.70	2.92	2.25	2.51	2.62	8.40
...	3.70	3.71	7.42	3.46	3.62	5.82	2.68	2.88	2.25	2.50	2.64	6.50
...	3.69	3.70	8.93	3.48	3.80	5.40	2.69	2.88	2.24	2.50	2.63	4.51
...	3.68	3.68	6.81	3.52	3.82	3.58	3.48	2.64	2.22	2.48	2.58	3.92
...	3.69	3.68	4.58	3.52	3.71	3.41	3.30	2.63	2.25	2.49	2.59	2.94
...	3.69	3.72	13.00	3.51	3.74	3.40	3.10	2.60	2.28	2.52	3.57	2.94
...	3.69	3.74	12.00	3.48	3.78	2.56	2.93	2.60	2.28	2.52	2.57	2.90
...	3.66	3.74	8.55	3.49	3.52	2.58	2.84	2.48	2.23	2.57	2.49	2.53
...	3.68	3.70	6.54	3.61	2.90	2.47	3.91	2.42	2.20	2.60	2.54	2.52
...	3.67	3.69	4.88	3.60	2.80	2.75	4.28	2.41	2.21	2.60	2.70	2.41
...	3.67	3.68	4.32	3.72	2.50	2.70	4.20	2.41	2.21	2.50	2.71	2.40
...	3.69	3.60	4.28	3.72	2.47	3.15	3.90	2.40	2.26	2.50	2.77	2.42
...	3.58	3.65	3.92	3.70	2.46	3.10	3.90	2.39	2.65	2.50	2.89	2.42
...	3.52	10.25	4.78	3.78	2.30	3.00	3.91	2.38	2.50	2.50	3.42	2.43
...	3.59	6.72	4.74	3.74	2.31	3.31	3.88	2.37	2.41	2.60	3.50	2.41
...	3.58	.....	5.70	3.79	2.36	3.30	3.86	2.37	2.41	2.58	2.93	2.42
...	3.59	.....	5.90	3.70	3.36	3.00	3.86	2.24	2.40	2.57	2.90	2.42
...	3.57	.....	5.00	.....	2.34	.....	3.71	2.26	.....	2.57	.....	2.39

HIWASSEE RIVER AT MURPHY, NORTH CAROLINA.

assee River rises in the northern part of Georgia and flows gh the southwestern corner of North Carolina into Tennessee, it empties into Tennessee River. The watershed is broken and ainous for the most part and well covered with forest. The rained is 410 square miles, and is mapped on the Murphy, Nan-, and Dahlonega atlas sheets. The river is measured at two , Murphy, North Carolina, and Charleston, Tennessee, 17 miles its mouth. The station at Murphy, described in the Eighteenth al Report, Part IV, page 117, is located on the highway bridge ng the river at Murphy, North Carolina, one-half mile above r River, and was established by E. W. Myers July 26, 1896. The age was last verified on December 29, 1899. The length of the is 29.10 feet. The section here is a fairly good one, though hat obstructed by the remains of two old piers directly under esent bridge. The course of the stream is straight for several ed yards above and below the bridge, and the current fairly The bottom is hard and rocky and not subject to any decided e by high water. The observer is M. L. Brittain, Murphy, North na. The results of measurements may be found as follows: 7, Nineteenth Annual Report, Part IV, page 269; 1898, Twen-

tieth Annual Report, Part IV, page 209. The following measurements were made by E. W. Myers and R. E. Shuford in 1899:

February 28, gage height, 7.50 feet; discharge, 2,150 second-feet.
June 23, gage height, 5.17 feet; discharge, 400 second-feet.
June 23, gage height, 5.30 feet; discharge, 436 second-feet.
September 28, gage height, 4.93 feet; discharge, 304 second-feet.
September 28, gage height, 5.00 feet; discharge, 345 second-feet.
December 7, gage height, 5.10 feet; discharge, 317 second-feet.
December 29, gage height, 5.50 feet; discharge, 613 second-feet.

Daily gage height, in feet, of Hiwassee River at Murphy, North Carolina, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.80	5.60	6.90	6.80	5.85	5.30	.....	5.30	5.40	4.90	4.85	5.10
2	5.70	5.70	6.60	6.60	5.82	5.30	.....	5.20	5.25	4.80	4.90	5.35
3	5.70	5.70	6.70	6.50	5.80	5.30	.....	5.20	5.50	4.85	4.90	5.10
4	5.65	14.00	6.32	7.20	5.80	5.25	.....	5.15	5.30	4.75	4.90	5.10
5	5.60	9.60	7.40	6.55	6.10	5.25	.....	5.12	5.20	4.80	4.90	5.10
6	5.70	9.45	6.75	6.50	5.80	5.25	.....	5.20	5.10	4.90	4.90	5.02
7	6.30	9.90	6.50	6.55	5.85	5.10	.....	5.20	5.10	4.90	4.90	5.00
8	6.00	7.85	6.40	6.70	5.70	5.10	.....	5.20	5.15	5.70	4.90	5.10
9	5.90	7.20	6.40	6.60	5.70	5.20	5.20	5.12	5.05	5.15	4.90	5.05
10	5.80	6.75	6.30	6.50	5.70	5.15	5.10	5.15	5.00	5.00	4.90	5.10
11	5.80	6.60	6.20	6.40	5.62	5.10	5.10	5.15	5.20	5.02	4.90	5.10
12	5.80	6.55	6.10	6.30	5.62	5.82	5.05	5.10	5.10	5.00	4.85	9.10
13	5.70	6.30	6.10	6.20	5.60	5.80	5.00	5.10	5.00	4.90	4.85	6.30
14	5.70	6.40	6.75	6.20	5.55	5.50	5.00	5.05	5.00	4.80	4.90	5.82
15	5.75	6.40	10.80	6.10	5.60	5.35	5.00	5.20	5.00	5.00	4.90	5.70
16	5.75	6.30	8.75	6.10	5.50	5.25	5.00	5.32	4.90	5.00	4.90	5.50
17	5.75	6.25	7.50	6.05	5.50	5.30	5.10	5.20	5.00	5.00	4.90	5.40
18	5.70	6.25	7.10	6.00	5.50	5.20	5.30	5.10	5.00	4.95	4.90	5.40
19	5.70	6.00	18.40	6.00	5.60	5.20	5.20	5.00	5.00	5.10	4.85	5.30
20	5.70	6.10	8.70	6.00	5.50	5.15	5.10	5.00	5.10	5.00	4.85	5.50
21	5.70	6.10	7.60	6.00	5.45	5.10	5.30	5.00	5.00	5.00	4.90	5.40
22	5.60	6.10	7.20	5.90	5.40	5.10	5.30	5.00	5.00	4.90	4.90	5.35
23	5.60	6.00	8.15	5.90	5.40	5.10	5.30	5.00	5.00	4.90	5.40	5.30
24	5.52	5.92	7.00	5.90	5.42	4.85	5.20	5.00	5.00	4.90	5.12	6.30
25	5.65	6.10	6.80	6.70	5.40	4.95	5.20	5.10	5.00	4.90	5.10	5.70
26	5.60	6.00	6.60	6.10	5.40	5.05	6.80	5.05	5.00	4.90	5.75	5.60
27	5.60	9.10	6.52	6.00	5.35	5.00	5.75	5.25	5.02	4.90	5.40	5.50
28	5.60	7.30	6.50	6.00	5.35	5.00	5.90	5.45	5.00	5.00	5.30	5.55
29	5.50	.....	6.90	5.90	5.32	5.00	.....	5.10	5.00	5.10	5.20	5.50
30	5.50	.....	6.70	5.90	5.32	5.00	.....	5.10	4.88	4.90	5.10	5.35
31	5.90	.....	7.80	.....	5.30	.....	.....	5.70	.....	5.00	.....	5.40

No readings July 1 to 9; gage broken.

HIWASSEE RIVER AT CHARLESTON, TENNESSEE.

The gaging station on this river is located at the bridge of the Southern Railway 600 feet from the depot in the town of Charleston, Tennessee. It is 17 miles above the mouth of the river and 53 miles above Chattanooga, Tennessee. The drainage area is mapped on the Cleveland, Murphy, Ellijay, Nantahala, Dahlonega, Dalton, Loudon, and Kingston atlas sheets. This station was originally established by the United States Engineer Corps, but is now maintained as a half-year station by the United States Weather Bureau, gage heights being kept from November 1 to April 31, inclusive. The gage rod is fastened to the downstream end of the south pier of the bridge, 125 feet from the shore. It is painted white and marked in feet and tenths. The bench mark is a cross cut in the top surface of the upper corner stone of the

, and is 35.00 feet above the zero of the gage. The greatest height ›rded at this point was on March 31, 1886, when the gage read 32.2 . The danger line is placed at 22 feet. The railroad bridge is an ı 3-span bridge, with a total length of 390 feet. There are embank- ıts at each end which confine the water, even at the highest stages, hin the banks. The observer is J. M. Bates, Charleston, Tennes- The following measurements were made by Max Hall in 1899:

May 6, gage height, 3.65 feet; discharge, 6,684 second-feet.
May 25, gage height, 2.05 feet; discharge, 3,730 second-feet.
September 16, gage height, 0.35 foot; discharge, 1,366 second-feet.
October 27, gage height, 0.20 foot; discharge, 1,194 second-feet.

aily gage height, in feet, of Hiwassee River at Charleston, Tennessee, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	Nov.	Dec.
1	2.60	4.30	7.20	9.40	0.50	1.00
2	2.80	3.40	5.90	7.20	.40	.80
3	2.40	3.10	5.30	6.10	.40	1.20
4	2.30	16.00	5.30	6.40	.40	1.00
5	2.30	21.60	7.30	7.90	.40	.80
6	4.00	18.60	8.90	6.50	.30	.70
7	8.30	22.40	8.10	6.30	.30	.70
8	6.70	20.90	7.50	11.00	.30	.60
9	4.90	16.50	5.60	7.80	.30	.60
10	3.90	13.50	4.50	7.10	.30	.60
11	3.40	8.90	4.30	6.00	.30	.60
12	3.50	5.90	4.00	5.60	.30	3.00
13	3.10	5.00	3.90	5.30	.30	7.00
14	2.90	3.70	5.70	5.00	.30	2.90
15	3.00	4.30	24.20	4.80	.30	2.10
16	2.90	4.80	27.30	4.60	.50	1.80
17	3.20	6.90	20.00	4.40	.50	1.40
18	3.30	5.60	14.40	4.10	.40	1.30
19	3.00	5.90	24.00	4.00	.40	1.30
20	2.80	5.30	27.60	4.00	.30	1.80
21	2.60	4.70	19.90	3.90	.30	2.00
22	2.50	4.60	16.60	3.70	.30	1.50
23	2.40	4.60	16.00	3.50	.70	1.40
24	2.40	4.20	13.00	4.50	1.70	3.20
25	2.70	3.90	8.70	4.60	1.00	3.70
26	2.70	3.70	7.60	6.00	.90	2.50
27	2.40	7.50	7.00	4.50	1.70	2.00
28	2.30	11.50	7.50	4.00	1.50	1.90
29	2.20	.....	10.60	3.70	1.20	2.00
30	2.20	.....	8.60	3.60	1.00	1.70
31	2.40	.....	8.00	.....	.....	1.10

No readings May 1 to October 31.

. measurement of Hiwassee River at Reliance, Tennessee, was made Max Hall, October 25, 1899: Gage height, 2.60 feet; discharge, 607 ›nd-feet.

TOCCOA RIVER AT BLUERIDGE, GEORGIA.

his stream has its source on the northern slopes of the Blue Ridge ıntains, in Georgia, and flows northwesterly into Hiwassee River. › area is covered with a fine growth of oak, hickory, and other hard ›ds, and is mapped on the Ellijay and Dahlonega atlas sheets. The ›ion, established by B. M. Hall on November 25, 1898, is located at Morganton bridge, about 4 miles east of the town of Blueridge, ›rgia. The gage is a 14-foot rod, in two 7-foot sections, nailed to a

tree on the right bank just below the bridge. It is graduated to feet and tenths, and is set to conform to bench marks which were established October 15, 1896, and October 26, 1898. The measurements during 1896 were made at the railroad bridge about 3 miles below, but are referred to the present gage by comparison of the bench marks at the two bridges. The bench mark at Morganton bridge is on the top of the bridge floor, on the downstream side, 50 feet from the initial point, and is 18.00 feet above zero of gage. This bridge is a wooden, queen-post, open bridge, in three spans, with a total length between abutments of 153 feet. The width of the river, including the two piers, at ordinary stages is 143 feet between banks, the three channels being 50, 38, and 33 feet. The observer is M. V. Pressley, a mail carrier who crosses the bridge twice daily, except on Sundays; no readings are had on this day, but figures have been interpolated. The following measurements were made by B. M. Hall and Max Hall during 1899:

April 28, gage height, 3.50 feet; discharge, 1,141 second-feet.
June 16, gage height, 2.70 feet; discharge, 522 second-feet.
September 18, gage height, 1.93 feet; discharge, 242 second-feet.
October 24, gage height, 1.90 feet; discharge, 222 second-feet.

Daily gage height, in feet, of Toccoa River at Blueridge, Georgia, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.10	3.20	4.30	4.20	3.70	3.00	2.50	2.60	2.80	2.00	2.10	2.40
2	3.00	3.20	4.00	3.60	3.50	2.10	2.45	2.60	2.40	2.00	2.00	2.30
3	2.90	3.30	4.10	3.11	3.50	2.10	2.40	2.50	2.40	1.90	2.00	2.10
4	2.90	5.90	4.10	4.60	3.40	2.20	2.40	2.50	2.50	1.90	2.00	2.10
5	2.10	6.70	4.00	4.40	3.10	3.00	2.50	2.50	2.40	1.90	2.00	2.10
6	3.02	8.90	4.00	3.90	3.60	2.90	2.80	2.50	2.40	2.00	2.00	2.00
7	3.04	6.10	3.80	4.50	3.40	2.90	2.70	2.50	2.30	3.00	2.00	2.00
8	3.08	5.50	3.70	4.80	3.20	2.90	2.80	2.40	2.30	2.80	2.10	2.00
9	3.10	5.00	3.60	4.00	3.20	2.70	2.75	2.30	2.30	2.60	2.10	2.00
10	3.10	4.00	3.10	4.00	3.10	2.70	2.75	2.30	2.50	2.30	2.10	2.50
11	3.20	3.70	3.00	3.10	3.00	2.70	2.70	2.30	2.60	2.10	2.10	3.60
12	3.00	3.80	3.50	3.90	3.00	3.40	2.70	2.60	2.50	2.00	2.10	3.50
13	3.00	3.90	4.00	3.80	3.00	3.20	2.80	3.40	2.30	2.00	2.00	3.30
14	3.10	4.00	4.00	3.70	3.00	3.00	2.70	3.40	2.30	2.00	2.00	2.90
15	3.10	4.00	4.90	3.70	3.00	2.10	2.60	3.40	2.20	2.00	2.10	2.80
16	3.10	4.10	6.00	3.60	3.00	2.70	2.40	3.20	2.20	2.00	2.10	2.50
17	3.20	3.10	4.40	3.60	3.00	2.60	2.40	2.40	2.10	2.00	2.00	2.40
18	3.10	3.30	4.00	3.60	3.00	2.60	2.80	2.40	2.30	2.00	2.00	2.30
19	3.00	3.40	4.50	3.60	3.30	2.60	2.70	2.40	2.30	2.00	2.00	2.60
20	3.00	3.60	5.00	3.60	3.00	2.60	2.70	2.20	2.00	2.00	2.00	2.60
21	2.10	3.50	4.80	3.60	3.20	2.50	2.80	2.20	2.00	2.00	2.00	2.50
22	3.00	3.60	4.60	3.60	3.20	2.45	2.80	2.20	2.00	2.00	2.00	2.40
23	3.80	3.50	5.60	3.80	3.10	2.60	2.60	2.30	2.00	2.00	2.00	2.50
24	3.10	3.40	5.00	4.00	3.10	2.10	2.50	2.20	2.00	2.00	2.00	.....
25	3.20	3.40	4.50	5.30	3.10	2.40	2.80	2.30	2.00	2.00	2.00	.....
26	3.10	4.00	4.20	4.10	3.10	2.70	2.80	2.20	2.00	2.00	2.30	.....
27	2.10	5.80	4.00	4.60	3.10	2.90	3.90	2.40	2.00	2.00	2.60	.....
28	2.10	4.90	4.00	3.10	3.00	2.85	3.60	2.60	2.00	2.00	2.30	.....
29	2.09	.....	4.00	3.00	3.00	2.70	2.80	2.50	2.00	2.20	3.30	.....
30	2.80	.....	4.00	3.30	3.10	2.60	2.80	2.60	2.00	2.40	3.10	.....
31	4.00	.....	4.80	.....	3.11	.....	2.80	2.70	.....	2.20	.....	.....

TENNESSEE RIVER AT KNOXVILLE, TENNESSEE.

This river is formed by the junction of French Broad and Holston rivers 4 miles above Knoxville. The drainage basin is mapped on *Knoxville*, Maynardsville, Morristown, Jonesville, Estillville, Bristol,

bingdon, Tazewell, Pocahontas, Greenville, Asheville, Roan Mountain, Cranberry, Mount Guyot, Mount Mitchell, Morganton, Saluda, isgah, Cowee, and Wytheville atlas sheets. The station was origi-ally established by the United States Weather Bureau, and was lo-ated at the old county highway bridge at Knoxville, which has lately een torn down. The new gage is situated at the Augusta and Knox-ille Railroad bridge. The datum of the new gage is 0.6 of a foot igher than that of the old one, so that this amount has to be added o the new readings to make them conform to the old standard. This orrection has been applied to the published heights of the Weather Bureau and of this Survey, both in the table of gage heights and in he list of discharge measurements. Measurements of discharge are made at the Cherokee highway bridge 2¼ miles below the gage, as there is at that point a better section for meter measurements. This bridge is a three-span iron bridge, and the width of water surface at low stages under it is 550 feet. The bridge is about 80 feet above low water. The following measurements were made by Max Hall during 1899:

May 4, gage height, 1.90 feet; discharge, 12,810 second-feet.
May 25, gage height, 1.70 feet; discharge, 10,134 second-feet.
September 16, gage height, 0.10 foot; discharge, 3,912 second-feet.
October 26, gage height, —0.60 foot; discharge, 2,728 second-feet.

Daily gage height, in feet, of Tennessee River at Knoxville, Tennessee, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	1.20	9.20	8.00	2.30	1.50	1.20	1.00	0.80	—0.10	—0.20	0.30
2	(a)	1.20	6.80	6.60	2.20	1.10	.90	.80	1.60	— .20	+ .40	.30
3	(a)	1.40	6.40	5.60	2.00	1.70	.60	.70	1.40	— .30	.50	.30
4	(a)	8.60	14.00	5.80	2.00	1.00	.40	.60	.80	— .30	.50	.40
5	(a)	16.70	14.40	8.20	2.40	1.40	.20	.40	.60	— .40	.50	.30
6	(a)	18.70	19.20	7.60	2.60	1.20	.40	.30	.40	— .40	.40	.30
7	(a)	22.50	16.40	6.00	3.80	1.10	.30	.20	.30	— .50	.30	.10
8	(a)	22.20	9.00	5.90	4.40	.90	.30	.20	.30	— .30	.10	.10
9	(a)	16.00	6.70	6.50	5.40	.90	.40	.20	.30	— .20	.00	.00
10	(a)	9.40	6.10	7.30	5.20	1.10	.40	.30	.30	— .60	— .10	— .10
11	(a)	6.00	5.10	6.20	4.40	1.20	.40	.30	.40	+ .80	— .20	— .20
12	(a)	5.00	4.60	5.20	4.00	1.40	.50	.70	.70	.70	— .20	.00
13	(a)	4.20	4.20	4.80	4.30	1.70	.30	.80	.60	.40	— .30	4.60
14	(a)	3.60	3.90	4.50	4.40	3.00	.20	.80	.40	.30	— .30	5.30
15	(a)	2.00	11.50	4.00	4.80	3.10	.10	.60	.30	.20	— .40	4.90
16	(a)	2.40	20.40	3.80	4.80	3.70	.00	.60	.20	.10	— .50	3.30
17	2.40	3.40	17.40	3.50	3.00	2.40	.00	.50	.10	.00	— .50	2.60
18	2.50	7.00	11.00	3.20	2.40	2.00	.10	.30	.00	.10	— .60	1.90
19	2.40	6.60	18.00	2.90	2.20	1.60	.20	.20	— .10	— .10	— .60	1.80
20	2.20	5.70	28.00	2.80	2.10	1.40	.40	.10	.00	— .20	— .60	1.80
21	2.10	4.80	25.40	2.60	1.90	1.20	.40	.00	.20	— .20	— .70	1.60
22	1.80	4.30	13.60	2.50	1.80	1.00	.40	.10	.50	— .30	— .70	1.90
23	1.60	4.40	10.10	2.30	1.80	.90	.30	.20	.40	— .30	— .70	1.80
24	1.50	4.40	7.80	2.20	1.70	.70	.20	.30	.20	.40	— .60	2.10
25	1.50	3.90	7.00	2.40	1.70	.80	.30	.40	.00	— .50	.50	3.40
26	1.60	3.50	6.50	2.60	1.60	1.20	.30	.40	.00	— .50	— .50	3.70
27	1.60	5.20	7.60	3.00	1.40	1.00	1.40	.50	.20	— .60	— .40	3.20
28	1.50	9.40	9.20	2.70	1.30	1.10	1.30	.60	.20	— .60	— .20	2.50
29	1.30	.....	12.20	2.60	1.20	1.60	2.10	.60	.10	.60	+ .20	2.20
30	1.20	.....	12.10	2.50	1.20	1.40	2.60	.00	.00	— .40	.30	1.70
31	1.20	.....	10.40	.....	1.30	.....	1.40	.00	.....	— .40	.....	1.70

a January 1 to 16, no readings; gage obstructed by false work of new bridge.

Clinch River, a tributary of Tennessee River, was measured at Clinton, Tennessee, on May 5, at a gage height of 7.55 feet, and showed a discharge of 5,220 second-feet.

TENNESSEE RIVER AT CHATTANOOGA, TENNESSEE.

This river, after passing Chattanooga, enters Alabama. It then makes a bend to the west and later to the north, returning to Tennessee. Flowing through this State and Kentucky, it empties into the Ohio 50 miles above Cairo. In 1879 a gage was established at Chattanooga, Tennessee, at the foot of Lookout street, just below Chattanooga Island, by the Signal Corps of the United States Army, which has been in charge of the Weather Bureau since July 1, 1891. The drainage area above this station is 21,382 square miles, and is mapped on Morristown, Greenville, Roan Mountain, London, Knoxville, Mount Guyot, Asheville, Murphy, Briceville, Standingstone, Wartburg, Pikeville, Maynardville, Cumberland Gap, Jonesville, Estillville, Bristol, Whitesburg, Grundy, Abingdon, Tazewell, Pocahontas, Wytheville, Cranberry, Morganton, Mount Mitchell, Saluda, Pisgah, Como, Nantahala, Walhalla, Dahlonega, Ellijay, Dalton, Cleveland, Ringgold, Kingston, and Chattanooga atlas sheets. The gage is on an inclined railroad iron for about 20 feet of its lower portion. Above this it is a vertical rod bolted to the rock bluff forming the river bank. The zero of the gage is 630.64 feet above sea level. Measurements are made from the Hamilton County steel highway bridge at the foot of Walnut street, a short distance below the gage. Gage heights are obtained from L. M. Prindell, United States Weather Bureau observer. Records of measurement may be found as follows: 1890 to 1895, Eighteenth Annual Report, Part IV, page 120; 1896–97, Nineteenth Annual Report, Part IV, page 261; 1898, Twentieth Annual Report, Part IV, page 210. The following measurements were made by Max Hall and others during 1899:

May 3, gage height, 6.71 feet; discharge, 37,770 second-feet.
May 26, gage height, 4.76 feet; discharge, 25,526 second-feet.
June 21, gage height, 4.15 feet; discharge, 21,391 second-feet.
September 15, gage height, 1.90 feet; discharge, 10,819 second-feet.
October 27, gage height, 0.80 foot; discharge, 6,566 second-feet.

East Chickamauga Creek, a tributary of the Tennessee, was measured at Anderson upper ford, 3 miles from Ringgold, Georgia, October 26, and gave a discharge of 35 second-feet.

ly gage height, in feet, of Tennessee River at Chattanooga, Tennessee, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.75	5.70	19.25	22.80	7.60	4.15	3.45	4.20	2.20	1.20	1.10	1.70
2	4.95	5.65	17.60	19.50	7.10	4.25	3.30	3.55	2.35	1.10	1.10	1.70
3	5.30	5.60	15.15	14.90	6.70	4.40	3.05	3.05	2.80	1.05	1.05	1.70
4	5.80	10.70	14.15	12.95	6.30	4.85	2.80	2.75	3.05	.95	1.10	1.70
5	5.95	23.10	17.95	13.25	6.15	4.65	2.60	2.45	2.65	.90	1.50	1.80
6	7.25	30.45	24.50	14.70	7.10	4.25	2.60	2.45	[illegible].25	.80	1.50	1.70
7	18.80	34.30	26.55	15.70	8.50	4.05	2.65	2.40	1.95	.85	1.50	1.60
8	18.40	36.95	27.60	18.05	9.35	3.75	3.05	2.40	1.80	1.00	1.45	1.50
9	17.55	38.25	27.70	17.75	10.00	3.55	2.90	2.25	1.60	1.15	1.35	1.40
10	17.15	36.75	16.15	15.70	10.70	3.40	2.60	2.10	1.80	1.60	1.20	1.40
11	13.85	30.30	11.85	14.20	11.15	3.90	2.55	2.10	1.70	1.80	1.15	1.60
12	10.50	19.35	10.60	12.90	10.40	4.30	2.45	2.00	2.00	1.85	1.10	5.20
13	9.15	12.15	9.55	11.65	9.60	5.25	2.30	2.00	1.80	1.70	1.00	6.45
14	8.10	9.50	11.20	10.70	9.30	5.80	2.20	2.25	2.00	1.65	1.00	7.40
15	7.55	8.50	24.55	10.00	9.55	6.45	2.15	2.65	1.85	1.40	1.00	7.15
16	7.30	7.55	34.25	9.40	9.20	6.10	1.95	2.65	1.65	1.25	1.00	6.20
17	7.40	7.95	36.90	8.75	8.70	6.40	1.90	2.40	1.45	1.15	1.00	5.20
18	7.45	9.55	36.15	8.40	7.75	6.20	1.80	2.30	1.35	1.15	1.00	4.25
19	7.25	11.30	35.85	8.00	6.90	5.25	1.90	2.15	1.20	1.10	1.00	3.85
20	7.00	12.65	37.05	7.55	6.40	4.70	2.05	1.90	1.05	1.10	.95	4.25
21	6.80	11.50	39.20	7.35	5.90	4.20	2.05	1.70	1.00	1.10	.85	4.40
22	6.45	10.65	40.00	7.05	5.60	3.75	2.40	1.60	1.05	1.10	.85	4.40
23	5.90	10.10	38.70	7.85	5.35	3.50	2.70	1.45	1.30	1.05	1.00	4.15
24	5.65	9.75	32.70	9.65	5.30	3.25	3.50	1.30	1.50	1.00	1.15	5.65
25	6.05	9.50	23.15	9.35	5.05	3.15	3.40	1.20	1.50	.95	1.30	6.15
26	6.35	9.20	16.30	10.75	4.80	3.00	3.00	1.20	1.45	.85	1.70	6.30
27	5.85	13.20	13.65	10.30	4.65	3.25	3.05	1.20	1.30	.80	1.80	5.85
28	5.75	18.45	13.95	9.20	4.40	3.65	3.65	1.25	1.20	.80	1.85	5.55
29	5.55	.....	17.30	8.35	4.30	3.50	4.25	1.50	1.25	.90	1.80	5.10
30	5.30	.....	21.20	7.75	4.20	3.30	4.25	1.85	1.30	1.00	1.75	4.65
31	5.30	.....	22.80	.....	4.25	.....	5.15	1.75	.....	1.05	.....	3.85

OLENTANGY RIVER AT COLUMBUS, OHIO.

This river rises in the north-central part of Ohio and flows in a ıtherly direction into the Scioto at Columbus. Its watershed is in ıeral flat and for the most part cultivated. Systematic measure-ents were begun in Columbus on November 22, 1898, when the sta-n at the Fifth avenue bridge was established by H. A. Pressey, of. C. N. Brown, and B. H. Flynn. The gagings are made on the stream side of the bridge, the initial point being on the left bank. wooden post, graduated to feet and tenths, was driven in the bed the stream near the bridge as a gage, and referred to a scale cut in e face of the left abutment, from which high-water readings can be ken directly. The observations of river heights are made under e direction of Prof. C. N. Brown, of the Ohio State University. ıe students in civil engineering have for the last two years studied e rainfall and run-off of the basin of the Olentangy and Scioto ers. A description of the watershed and the results of observa-ıns may be found in the Twentieth Annual Report, Part IV, page 5. The following measurements were made during 1899:

Measurements of Olentangy River at Columbus, Ohio.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
Jan. 5	5.71	5,335	Mar. 25	3.25	1,717
Jan. 15	7.90	9,236	Mar. 27	3.15	1,546
Mar. 15	1.87	387	Mar. 31	3.67	2,321
Mar. 16	1.97	477	Apr. 6	1.70	326
Mar. 20	3.58	2,356	Apr. 17	1.45	180
Mar. 22	2.95	1,430	Apr. 22	1.33	126
Mar. 24	4.54	3,174	Sept. 16	0.90	5
Do	4.21	2,910			

Daily gage height, in feet, of Olentangy River at Columbus, Ohio, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.95	1.55	2.65	3.76	1.24	2.20	1.15	1.20	1.10	1.00	1.10	1.10
2	1.70	1.55	2.65	2.80	1.28	2.50	1.10	1.20	1.10	1.00	1.10	1.10
3	2.10	1.55	2.57	2.24	1.19	3.00	1.10	1.20	1.10	1.00	1.15	1.20
4	1.94	1.55	2.90	1.98	1.27	2.55	1.10	1.40	1.10	1.00	1.20	1.20
5	5.53	1.55	4.37	1.82	1.27	2.00	1.10	1.50	1.10	1.00	1.20	1.20
6	5.17	1.55	4.25	1.73	1.17	1.75	1.10	3.10	1.10	1.00	1.20	1.20
7	3.80	1.55	3.00	1.70	1.60	1.85	1.10	2.45	1.10	1.00	1.20	1.20
8	2.57	1.55	2.14	2.00	1.56	1.55	1.10	2.10	1.10	1.00	1.20	1.20
9	2.18	1.55	2.07	2.45	1.38	1.45	1.10	1.75	1.10	1.00	1.20	1.20
10	2.06	1.55	2.07	2.45	1.28	1.50	1.10	1.45	1.00	1.00	1.20	1.20
11	1.87	1.55	2.32	2.05	1.34	1.40	1.10	1.40	1.00	1.00	1.10	1.20
12	1.77	1.55	2.80	1.83	1.18	1.40	1.10	1.35	1.00	1.00	1.10	1.55
13	1.90	1.55	2.57	1.72	1.27	1.30	1.10	1.30	1.00	1.00	1.10	1.90
14	8.45	1.55	2.20	1.75	1.20	1.30	1.15	1.25	1.00	1.00	1.20	1.90
15	8.20	1.55	1.90	1.66	1.20	1.30	1.10	1.20	1.00	1.00	1.20	1.50
16	5.90	1.55	1.88	1.55	1.20	1.20	1.30	1.20	1.00	1.00	1.20	1.45
17	4.07	1.55	1.98	1.48	1.14	1.20	1.35	1.20	1.00	1.00	1.20	1.50
18	2.98	1.55	1.87	1.42	1.17	1.30	1.30	1.20	1.00	1.00	1.20	1.50
19	2.53	2.22	3.42	1.40	1.27	1.25	1.40	1.20	1.00	1.00	1.20	1.90
20	2.10	2.17	3.65	1.36	1.20	1.25	1.55	1.10	1.00	1.00	1.20	3.30
21	1.98	1.87	3.04	1.35	1.25	1.30	1.45	1.10	1.00	1.00	1.20	2.75
22	1.88	2.38	2.80	1.33	1.30	1.45	1.30	1.10	1.00	1.00	1.20	2.20
23	1.80	3.92	5.19	1.29	1.40	2.35	1.30	1.10	1.00	1.00	1.20	1.85
24	1.80	2.87	4.43	1.30	1.25	1.90	1.25	1.10	1.00	1.00	1.20	1.80
25	1.87	1.88	3.38	1.31	1.20	1.65	1.40	1.10	1.00	1.00	1.20	1.80
26	1.80	1.87	3.67	1.27	1.20	1.45	1.50	1.10	1.00	1.00	1.20	1.80
27	1.78	3.97	3.48	1.31	1.25	1.25	1.30	1.10	1.00	1.00	1.20	1.80
28	1.55	3.52	3.64	1.45	1.25	1.20	1.30	1.10	1.00	1.05	1.20	1.80
29	1.55	.....	3.73	1.35	1.35	1.20	1.20	1.10	1.00	1.10	1.15	1.80
30	1.55	.....	3.12	1.30	1.60	1.20	1.20	1.10	1.00	1.10	1.10	1.80
31	1.87	.....	3.64	.....	1.95	.....	1.20	1.10	.....	1.10	.....	1.80

SCIOTO RIVER AT COLUMBUS, OHIO.

This river drains the central portion of the State of Ohio, and flows in a general southerly direction into Ohio River near the city of Portsmouth. Its watershed is flat and highly cultivated above Columbus, while in the southern part it is hilly, with comparatively little cultivation. A description of the watershed and results of measurements may be found in the Twentieth Annual Report, Part IV, page 212. Systematic measurements were begun at Columbus November 22, 1898, when a station was established by H. A. Pressey, Prof. C. N. Brown, and B. H. Flynn. It is located at the Grandview avenue bridge in Columbus. The wire gage is located on the upstream side of the bridge, and is referred to a scale cut in the face of the left abutment, from which high-water readings can be taken directly. The river bed at the station is rocky. The banks are naturally low, but levees have been built on each side in order to prevent overflow; high water seldom reaches the top of the levees, but occasionally they are overflowed. The following measurements were made under the direction of Prof. C. N. Brown during 1899:

Measurements of Scioto River at Columbus, Ohio.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
Jan. 15	19.50	13,895	Mar. 27	14.05	3,379
Jan. 20	13.00	2,291	Mar. 29	14.56	3,894
Mar. 6	15.50	5,367	Apr. 5	11.76	982
Mar. 8	13.35	2,457	Apr. 8	11.94	1,116
Mar. 9	12.89	1,995	Apr. 14	11.30	668
Mar. 17	11.61	942	Apr. 16	11.02	531
Mar. 20	14.05	3,271	Apr. 18	10.72	341
Mar. 22	14.30	3,905	Apr. 22	9.90	236
Mar. 24	15.00	4,526	Apr. 26	9.80	203
Do	14.57	4,050	Sept. 16	9.10	23
Mar. 25	14.58	3,919			

Daily gage height, in feet, of Scioto River at Columbus, Ohio, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	11.25	10.65	13.80	14.15	9.60	10.35	9.10	9.50	9.10	9.05	9.45	9.45
2	11.30	10.80	13.60	13.30	9.75	10.35	9.00	9.40	9.10	9.20	9.35	9.40
3	10.95	10.50	13.15	12.70	9.85	10.70	9.10	9.40	9.00	9.25	9.30	9.40
4	11.50	10.45	13.65	12.10	9.80	10.90	9.10	9.30	9.00	9.20	9.35	9.35
5	16.00	10.35	15.85	11.75	9.70	10.40	9.10	9.35	9.00	9.20	9.40	9.30
6	15.75	10.40	15.65	11.50	9.65	10.20	9.10	12.70	9.00	9.10	9.35	9.30
7	14.25	10.40	14.55	11.40	9.60	10.00	9.50	11.95	9.00	9.00	9.40	9.40
8	13.50	10.35	13.60	11.95	9.85	9.70	9.30	11.10	9.00	9.00	9.30	9.30
9	13.25	10.30	13.00	12.25	9.75	9.70	9.05	10.65	9.00	9.00	9.25	9.30
10	12.25	10.30	12.55	12.15	9.70	9.65	8.90	10.20	9.00	9.05	9.25	9.30
11	11.45	10.40	12.80	11.85	9.70	9.55	8.90	9.95	9.00	9.10	9.35	9.35
12	11.20	10.40	13.05	11.55	9.75	9.45	9.00	9.75	9.00	9.10	9.25	9.50
13	11.70	10.30	12.90	11.35	9.80	9.40	9.00	9.55	9.00	9.10	9.15	9.65
14	20.30	10.30	12.45	11.30	9.70	9.40	9.30	9.45	8.95	9.10	9.30	10.10
15	19.65	10.30	11.95	11.15	9.60	9.30	9.35	9.35	8.95	9.10	9.25	10.00
16	17.85	10.25	11.85	10.95	9.60	9.40	9.50	9.30	9.00	9.10	9.20	9.90
17	16.80	10.20	11.65	10.85	9.60	9.30	9.75	9.30	9.05	9.10	9.30	9.80
18	15.40	10.80	12.25	10.70	9.55	9.25	9.95	9.20	9.10	9.15	9.30	9.80
19	14.05	11.10	14.30	10.70	9.60	9.20	9.85	9.20	9.00	9.15	9.30	9.95
20	13.10	11.25	14.10	10.50	9.60	9.25	9.90	9.20	8.90	9.15	9.30	11.55
21	12.55	11.40	13.95	10.15	9.60	9.20	9.90	9.20	8.95	9.10	9.35	11.30
22	11.95	12.60	14.20	9.75	9.70	9.20	9.65	9.10	9.05	9.10	9.45	11.20
23	11.65	13.45	16.40	9.85	9.55	9.20	9.60	9.10	9.05	9.10	9.30	10.85
24	11.50	12.60	14.95	9.80	9.55	9.20	9.50	9.00	9.05	9.10	9.25	10.55
25	11.55	12.25	14.60	9.80	9.50	9.15	10.35	9.10	9.00	9.10	9.25	10.30
26	11.40	12.85	15.45	9.85	9.40	9.10	9.75	9.10	9.00	9.10	9.35	10.25
27	11.10	15.15	14.25	9.80	9.40	9.15	10.20	9.10	9.00	9.10	9.30	10.15
28	10.65	14.25	15.05	9.75	9.40	9.10	10.05	9.10	9.05	9.25	9.30	10.10
29	10.80	.....	14.85	9.70	9.50	9.10	9.75	9.10	9.00	9.40	9.35	10.10
30	11.00	.....	14.00	9.70	9.50	9.10	9.70	9.10	9.00	9.40	9.30	9.95
31	11.05	.....	14.90	.....	9.75	.....	9.65	9.10	.....	9.40	.....	9.90

LAKE SUPERIOR OUTFLOW.

In December, 1895, and January, 1896, the United States engineers neasured the outflow of Lake Superior under each of the spans of the nternational bridge.[1] From these and other measurements made at Spry's dock, about a mile below the rapids, the discharge at various stages of the river was computed as shown in the following table:

Discharge of St. Marys River at various stages.

Stage of river.	Discharge.
Feet.	*Second-feet.*
600.6	57,440
601.2	67,310
602.0	81,210
603.0	99,770

[1] From report by Alfred Noble, civil engineer, May 25, 1897, in Report on Compensating Works, Michigan Lake Superior Power Company, Sault Ste. Marie, Michigan, September, 1899.

It is proposed to withdraw from St. Marys River about 30,000 second-feet by a canal traversing the city of Sault Ste. Marie, Michigan, pass it through turbines installed below the Government pier and return it to the river. The turbine shafts are to be coupled directly to electric generators which are to develop 40,000 effective horsepower. The section of this canal in rock will be about 200 feet wide and carry 22 feet of flowing water. The available head has been assumed to be 19 feet, and from this a little less than 3 feet is deducted for losses by friction and other causes, leaving an effective head of a trifle over 16 feet, as given by the report of Mr. H. von Schon.

The above-described measurements were made by Mr. E. E. Haskell, assistant engineer, and briefly noted in the annual report of the Chief of Engineers, United States Army, 1896, page 4027. In the next annual report, that for 1897, on pages 4092 to 4104, are details of measurements made by Mr. E. E. Haskell during February and March, 1896. The discharge section was in the reach of river extending from the foot of St. Marys Rapids to the head of Little Rapids. It began at the foot of Spry's dock on the American side of the river and ended at Plummer's dock on the Canadian side. The total water width at this point is 2,483 feet. The river was frozen at the time of making observations, and the section was sounded and current observations made through the ice. At this time the attempt was made to measure low velocities by means of a hydrometric pendulum, but the results obtained with this instrument were not satisfactory. It was found that the friction caused by the ice was practically 31 per cent of that caused by the bottom. The discharges as measured varied from 60,470 to 77,290 second-feet.

In addition to the measurements of the outflow of Lake Superior similar work has been done on the St. Clair and Niagara rivers, results of which are to appear in the annual report of the Chief of Engineers for the year ending June 30, 1900. Investigations of Detroit and St. Lawrence rivers and additional details concerning St. Marys River are being obtained for publication a year later.

MAUMEE RIVER AT WATERVILLE, OHIO.

Maumee River is formed by the junction of St. Joseph and St. Marys rivers near Fort Wayne, Indiana, and flows in a northeasterly direction through Ohio, emptying into Lake Erie at Toledo. The southern part of the watershed is flat, the northern part being gently rolling and hilly in places. Formerly the hilly section was covered with timber, all of the best of which has been cut, leaving a section of scrub timber, with occasional farms cleared and cultivated. At the station the bed of the stream is rocky and the current sluggish, the fall being only 1.1 feet per mile on an average. Two dams have been built on the Maumee—one at Defiance, to supply water for the Ohio State

canals, and one at Grand Rapids for furnishing water power. A station was established on this river by H. A. Pressey and B. H. Flynn November 19, 1898. It is located at the highway bridge near Waterville, the gagings being made on the downstream side of the bridge. Zero of gage is on the left bank, marked by a nail in the guard rail. The wire gage is referred to a bench mark cut in the upstream side of the abutment on the left bank of the river. The elevation is 25.2 feet above gage datum. This is the lowest place on the river at which gagings can be made without being affected by backwater from the lake. The observer is J. E. Harper, station agent at Waterville, Ohio. Two measurements of discharge were made by B. H. Flynn and H. A. Pressey during 1899, as follows: The first, on March 3, at a gage height of 6.18 feet, gave a discharge of 15,490 second-feet; the second, on September 25, at a gage height of 2.15 feet, gave a discharge of 125 second-feet.

Daily gage height, in feet, of Maumee River at Waterville, Ohio, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.35	3.00	7.60	5.70	3.00	3.05	2.10	2.25	2.40	2.00	2.35	2.30
2	4.35	3.15	7.70	5.25	2.95	3.00	2.10	2.35	2.45	2.00	2.45	2.20
3	4.05	3.35	6.10	5.50	3.00	3.00	2.05	2.35	2.45	2.00	2.50	2.20
4	4.30	3.35	6.85	5.20	2.85	3.15	2.05	2.35	2.40	2.00	2.40	2.15
5	5.15	3.45	6.75	5.25	2.80	3.25	1.95	2.25	2.55	2.00	2.40	2.10
6	5.70	2.75	6.85	5.10	2.80	3.10	2.05	3.55	2.70	2.00	2.35	2.10
7	5.50	3.20	6.55	4.90	2.80	3.20	2.05	4.05	2.65	2.00	2.45	2.05
8	5.15	3.80	5.60	4.90	2.95	3.10	2.10	3.75	2.55	2.00	2.60	2.00
9	4.40	3.80	5.10	4.80	3.15	3.00	2.05	3.70	2.50	2.10	2.90	2.00
10	4.45	3.80	4.80	4.70	3.25	2.95	2.10	3.60	2.40	2.10	2.90	2.00
11	4.45	3.80	5.35	4.55	3.05	2.95	1.90	3.60	2.35	2.00	2.85	2.10
12	4.10	3.80	7.00	4.30	2.95	2.95	2.00	3.60	2.30	2.00	2.90	2.20
13	3.80	3.80	8.70	4.20	2.75	2.85	2.05	3.50	2.25	2.00	2.75	2.25
14	5.00	3.80	7.75	4.20	3.05	2.80	1.90	3.40	2.20	2.00	2.75	2.30
15	8.50	3.80	6.95	4.10	3.35	2.55	1.85	3.40	2.15	1.90	2.60	2.40
16	9.50	3.80	6.30	3.20	3.30	2.50	1.80	3.05	2.10	1.90	2.50	2.45
17	9.65	3.80	6.90	3.75	3.30	2.40	1.85	2.80	2.10	1.95	2.35	2.60
18	8.80	3.80	5.95	3.65	3.15	2.35	2.05	2.55	2.00	2.10	2.25	2.75
19	7.85	3.50	7.35	3.45	3.25	2.40	2.40	2.30	2.00	2.15	2.20	3.05
20	6.55	2.95	9.25	3.50	3.35	2.30	2.80	2.20	2.00	2.20	2.20	3.90
21	5.65	3.00	9.50	3.15	3.15	2.15	2.75	2.20	2.00	2.20	2.15	4.50
22	4.90	4.05	8.90	3.00	3.15	2.10	2.65	2.15	2.00	2.10	2.20	5.25
23	4.50	4.50	8.35	3.05	3.35	2.20	2.60	2.10	2.00	2.10	2.35	5.05
24	4.20	5.20	8.10	3.20	3.15	2.30	2.40	2.10	2.00	2.10	2.40	4.50
25	3.95	5.50	7.30	3.35	3.00	2.20	2.40	2.05	2.05	2.10	2.50	4.10
26	4.00	6.10	7.15	3.65	2.75	2.25	2.30	2.15	2.10	2.05	2.50	4.10
27	2.50	8.35	7.00	3.70	2.85	2.20	2.35	2.20	2.00	2.00	2.40	4.00
28	3.70	8.40	6.65	3.35	3.30	2.25	2.50	2.25	2.00	2.05	2.40	4.00
29	2.90	.....	6.10	3.10	3.30	2.20	2.45	2.30	2.10	2.00	2.40	4.00
30	3.00	.....	5.75	3.10	3.05	2.15	2.40	2.25	2.10	2.10	2.30	4.00
31	2.70	.....	5.65	.....	3.00	.....	2.35	2.35	.....	2.20	.....	4.00

SANDUSKY RIVER AT MEXICO, OHIO.

This river rises in the north-central part of Ohio and flows in a westerly and northerly direction into Sandusky Bay, an arm of Lake Erie. Its watershed is largely used for farming and pasturage, having only an occasional patch of forest. Sixteen dams have been built along its course in order to utilize the water power. Only five of these are now in use, but the flow is more or less obstructed by them all.

Measurements of flow were begun in November, 1898, in connection with the work of the State board of health in their study of the pollution of the Ohio streams and also to obtain information in regard to water power. Two stations have been established on the Sandusky, one at Mexico, 6 miles above Tiffin, and the other at Fremont, about 15 miles from the mouth of the river. The Mexico station was established by H. A. Pressey and B. H. Flynn on November 17, 1898, and is located at the highway bridge near Mexico, about 40 miles above Fremont, Ohio. The wire gage is on the upstream side of the bridge, and is referred to a bench mark cut in the top side of the upstream wing of the right abutment of the bridge. The elevation of the bench mark is 30.00 feet above gage datum. Gagings are made from the downstream side of the bridge, the initial point being on the left bank, marked by a nail in the guard rail. The stream flows through a long stretch of clay banks, with little sand and gravel, and is unobstructed near the point of measurement. At extreme high water the banks are overflowed, and at very low water the measurements are somewhat uncertain, owing to the sluggishness of the stream. The observer is M. L. Estep, of Mexico, Ohio. One measurement of discharge was made by B. H. Flynn in March, 1899, at a gage height of 5.40 feet, which gave a discharge of 1,386 second-feet.

Daily gage height, in feet, of Sandusky River at Mexico, Ohio, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.00	1.90	5.60	6.40	1.50	4.10	1.10	1.40	0.60	0.60	1.10	1.20
2	2.90	1.90	4.30	6.00	1.40	4.10	1.00	1.30	.50	.60	1.10	1.20
3	2.80	1.80	4.00	4.90	1.40	3.70	1.00	1.30	.60	.60	1.00	1.20
4	3.10	1.80	5.00	4.70	1.30	3.00	1.00	1.30	.50	.60	1.20	1.20
5	10.20	1.70	9.40	4.20	2.40	2.40	.90	1.20	.50	.60	1.20	1.30
6	10.80	1.70	10.80	3.40	1.90	2.00	.90	2.50	.50	.50	1.10	1.60
7	9.80	1.70	9.20	3.00	2.20	2.00	.90	2.10	.50	.50	1.10	1.40
8	6.10	1.60	6.30	4.80	2.00	2.50	.80	1.60	.60	.50	1.10	1.30
9	4.00	1.60	4.50	5.80	1.80	3.00	.80	1.40	.60	.50	1.10	1.20
10	3.50	1.60	4.00	5.00	1.60	2.40	.80	1.40	.60	.50	1.00	1.20
11	3.50	1.60	7.80	4.10	1.50	2.00	.80	1.40	.60	.50	1.00	1.20
12	3.40	1.60	8.40	3.20	1.40	1.80	.80	1.30	.60	.60	1.00	1.30
13	3.40	1.60	6.50	3.50	1.90	1.70	.70	1.30	.50	.60	1.00	1.60
14	10.20	1.60	4.80	3.40	1.50	1.50	.70	1.20	.50	.80	1.00	1.60
15	15.50	1.60	3.80	3.00	1.40	1.40	1.10	1.20	.50	.80	1.10	1.80
16	17.00	1.50	3.70	2.50	1.30	1.30	1.50	1.00	.50	.80	1.20	1.80
17	15.30	1.50	3.70	2.30	1.30	1.30	1.60	.90	.60	.80	1.20	1.70
18	10.30	1.50	3.90	2.00	2.20	1.20	1.50	.90	.60	.80	1.20	1.90
19	6.30	1.50	11.00	2.00	4.20	1.10	1.40	.90	.60	.70	1.20	2.20
20	4.20	1.50	11.80	1.90	3.20	1.00	1.30	.80	.80	.80	1.20	3.00
21	3.60	1.50	9.30	1.90	2.40	1.00	1.30	.80	.80	1.00	1.20	3.30
22	3.40	8.10	7.30	1.80	2.00	.90	1.30	.80	.70	1.00	1.10	2.80
23	3.20	9.20	9.30	1.80	1.80	.90	1.20	.80	.60	1.00	1.10	2.40
24	3.00	7.20	10.10	1.60	1.70	.80	1.20	.80	.60	1.00	1.20	2.20
25	3.00	5.00	9.50	1.80	1.60	1.30	1.20	.70	.60	1.00	1.20	2.20
26	2.90	5.40	7.40	1.80	1.60	1.20	1.20	.70	.60	1.00	1.20	2.10
27	2.70	9.20	6.40	1.80	1.50	1.20	1.10	.70	.60	1.10	1.20	2.10
28	2.60	8.40	6.00	1.80	1.50	1.20	1.20	.70	.60	1.10	1.30	2.00
29	2.40	.....	5.50	1.70	1.60	1.10	1.50	.60	.60	1.20	1.20	2.00
30	2.20	.....	6.10	1.60	3.40	1.10	1.50	.60	.60	1.20	1.20	1.80
31	2.00	.....	5.90	.....	4.70	.....	1.40	.60	.....	1.20	.....	1.60

SANDUSKY RIVER AT FREMONT, OHIO.

This station, established by H. A. Pressey and B. H. Flynn on November 18, 1898, is at the bridge of the Lake Shore Railroad at Fremont, Ohio. The gagings are made from the board walk on the lower cord of the bridge, the initial point being a cross cut on the bottom lateral at the west end of the bridge. The gage is an iron pipe graduated to feet and tenths, located at the waterworks intake, and is referred to a bench mark cut on top of south end of west abutment of bridge. The elevation of bench mark is 20.1 feet above gage datum. The bed is rocky, the banks high and not subject to overflow. During the summer of 1899, owing to the scarcity of water for the waterworks of Fremont, the rubble dam below the station was rebuilt, affecting the flow of the river and gage readings, especially at time of low water. The observer is Charles F. Reiff, superintendent of the waterworks at Fremont, Ohio. A measurement of discharge was made March 2, 1899, by B. H. Flynn: Gage height, 2.32 feet; discharge, 1,784 second-feet.

Daily gage height, in feet, of Sandusky River at Fremont, Ohio, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.00	1.30	2.95	2.90	0.40	2.20	−0.05	+0.05	0.35	0.75	0.95	0.90
2	1.75	1.20	2.25	2.75	.35	2.15	−.15	.10	.40	.70	.95	.90
3	1.70	1.20	2.05	2.45	.30	1.95	−.25	.05	.35	.75	1.05	.95
4	2.30	1.20	2.75	2.55	.40	1.55	−.25	.00	.40	.75	1.05	1.00
5	5.15	1.20	4.80	2.30	1.55	1.10	−.15	.00	.35	.75	1.05	.95
6	4.90	1.10	4.55	1.95	1.00	.85	−.15	−.10	.40	.70	1.05	.95
7	4.40	1.10	3.75	1.80	.85	.80	−.15	+.55	.45	.60	.95	.95
8	3.25	1.05	2.95	2.75	.95	.75	.10	.25	.45	.60	.90	.95
9	2.70	.75	2.40	2.85	.75	1.40	−.20	.10	.45	.60	.90	.95
10	2.35	.70	2.65	2.50	.65	1.30	−.10	.00	.40	.60	.90	.90
11	2.15	.80	4.40	2.10	.50	1.00	+.05	.00	.40	.60	.90	1.00
12	2.15	.80	4.05	2.00	.45	.75	−.15	.00	.30	.45	.95	1.00
13	2.50	.80	3.15	1.95	.40	.55	−.15	−.15	.30	.50	.95	1.05
14	7.80	.80	2.10	1.75	.40	.35	−.20	−.10	.30	.70	.95	1.20
15	8.25	.80	2.10	1.50	.40	.30	−.20	−.10	.30	.70	.90	1.20
16	7.40	.75	1.95	1.25	.35	.20	+.60	−.15	.50	.75	.90	1.20
17	6.80	.80	1.90	1.05	.40	.20	.55	−.20	.50	.85	.95	1.10
18	5.00	1.00	2.85	.90	.85	.10	.35	−.15	.50	.85	.95	1.10
19	3.40	1.05	6.70	.80	1.55	.10	.15	−.20	.65	.95	.95	1.50
20	2.90	1.55	5.05	.80	1.55	.10	.10	−.25	.60	.85	1.00	1.90
21	2.55	2.05	4.05	.70	1.00	.00	.00	−.25	.55	.85	.95	1.90
22	2.25	4.25	4.00	.65	.75	.00	.05	−.25	.55	.85	.95	1.70
23	2.20	4.00	4.65	.60	.55	.00	−.10	−.25	.55	.85	.90	1.50
24	2.20	3.30	4.20	.60	.45	−.05	−.10	−.25	.65	.85	.95	1.40
25	2.30	2.50	3.80	1.15	.35	−.05	+.05	−.35	.80	.85	.95	1.50
26	2.15	3.40	3.60	1.00	.30	.00	.10	−.40	.70	.85	.95	1.25
27	2.10	4.20	3.10	.75	.35	−.05	.15	.30	.70	.85	.95	1.10
28	1.65	3.60	2.85	.70	.55	.00	−.15	−.35	.80	.95	.95	1.10
29	1.55	.....	2.80	.60	1.20	−.05	−.15	−.25	.80	.95	.95	1.10
30	1.45	.....	2.90	.55	2.15	−.05	−.15	.05	.70	.90	.90	1.00
31	1.35	.....	2.85	.....	2.50	.....	−.05	+.20	.....	1.05	.....	.95

NIAGARA RIVER BELOW BUFFALO, NEW YORK.

Measurements of Niagara River were made under the direction of the United States Board of Engineers on Deep Waterways, from September, 1897, to September, 1898, the work being in charge of E. E. Haskell, assistant engineer. The results are discussed in a paper prepared by Mr. Clinton B. Stewart, assisting Mr. Haskell, and presented to the Western Society of Engineers in December,

1899.[1] The point of measurement was on the north side of the international bridge, about 3 miles below the head of the river. At this point the total width is 1,806 feet, of which 128.5 feet is taken up by the width of the eight bridge piers. The distance between soundings was about 20 feet. The soundings were made with a 41-pound cast-iron weight attached to a sash chain, in swift and deep water, and with a 25-pound lead in the shallower water. Velocity measurements were made by means of Haskell current meters with high and low pitch wheels. The velocity of the current was determined at points about 80 feet apart and at 0.3 of the total depth. Measurements of velocity near the surface were also taken, with the meter immersed 1 foot, also near the bottom, with the weight just clearing, so that the meter wheel was 1.5 feet above the bottom.

At a water-surface elevation of 567.0 feet above mean tide at New York, the area of cross section was 39,629 square feet. The discharge measurements covered a range of about 2.3 feet in lake level. Taking the elevation of mean level of Lake Erie at 572.78, this being the average at Cleveland for the period 1875 to 1898, the corresponding discharge, when corrected, is placed at 221,500 second-feet. The rate of increase in discharge at this elevation is about 25,000 second-feet per foot rise.

In the results of this investigation published by Mr. Clinton B. Stewart in the Journal of the Western Society of Engineers, the gages showing height of water at the time of measurements were located, one on the American shore and the other on the Canadian shore, each about 2½ miles from the mouth of the river. These were read during the months of July and August, 1898, simultaneously at ten-minute intervals throughout the day. They have been referred to the gage near Buffalo, readings of which were made from 1887 to 1897. The fall from these to the latter is 0.13 foot. No attempt has been made to estimate the daily flow. It is probable that this can be done, as the bed of the river is of rock and not subject to change. The construction of the international bridge about 1870 may have changed the slope conditions slightly, but probably has not influenced the flow by more than a few per cent.

The measurements of the outflow of Lake Erie through Niagara River were continued from September, 1898, by the Corps of Engineers, United States Army, in charge of the survey of northern and northwestern lakes, of which Mr. E. E. Haskell was assistant engineer and Mr. F. C. Shenehon was resident engineer. From the measurements made by these two parties the outflow, by months, for the years 1895 to 1898 has been computed and published.[2] The mean discharge for these thirty-four years is 220,428 second-feet. The following table gives the results, by months, in condensed form:

[1] Journal of Western Society of Engineers for 1899, pp. 450 to 492.

[2] *Regulation of* the Level of Lake Erie. Fifty-sixth Congress, first session, H. R. Doc. No. 209, *pp. 15 and 16.*

monthly discharge of Niagara River below Buffalo, New York, for years 1865 to 1898, inclusive, in thousands of cubic feet per second.

.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
5.	205	193	200	216	231	230	229	227	226	219	210	206	216
6.	200	197	205	219	225	231	234	228	226	226	220	220	219
7.	213	206	215	223	236	244	239	231	221	213	202	197	220
8.	192	185	197	216	227	237	236	223	216	206	202	198	211
9.	197	196	206	214	227	237	245	242	235	223	212	221	221
0.	227	232	227	244	249	249	250	248	241	231	224	221	237
1.	216	208	219	231	238	238	238	232	228	212	207	198	222
2.	196	191	189	193	203	211	211	210	205	201	194	189	199
3.	187	187	189	217	234	236	236	234	224	217	212	221	216
4.	231	232	233	237	240	241	242	238	226	215	205	201	228
5.	196	192	195	204	215	225	229	228	225	213	209	214	211
6.	214	227	244	259	268	272	268	260	255	240	242	233	248
7.	223	219	214	224	230	232	239	235	233	223	221	223	226
8.	225	228	232	243	250	250	250	243	240	231	226	228	237
9.	217	214	214	223	227	229	230	225	216	211	200	206	218
0.	218	219	222	226	233	236	238	232	226	215	214	206	224
1.	196	199	206	223	233	239	238	230	221	220	215	220	220
2.	232	232	244	250	256	260	258	254	247	235	226	214	242
3.	212	217	221	224	236	255	261	259	250	242	232	232	237
4.	224	231	236	250	258	260	254	250	238	229	217	216	239
5.	211	206	203	223	242	256	255	255	251	248	245	243	236
6.	244	225	220	243	251	254	253	247	241	235	224	226	239
7.	220	230	252	253	258	259	252	243	237	222	215	216	238
8.	211	205	207	223	229	232	236	233	222	213	215	212	220
9.	212	209	205	213	217	228	233	225	216	206	200	206	214
0.	214	221	224	237	246	256	245	234	229	224	223	218	231
1.	212	212	223	220	215	219	216	210	206	197	188	189	209
2.	190	186	187	198	217	236	239	230	222	209	201	195	209
3.	187	189	193	210	230	235	228	220	210	202	194	195	208
4.	202	199	200	209	218	225	223	214	210	202	197	195	208
5.	188	184	184	189	194	196	193	192	189	180	178	181	187
6.	183	181	180	189	198	204	201	206	198	193	186	186	192
7.	186	190	198	210	218	220	220	216	210	198	196	195	205
8.	196	200	206	220	224	225	219	214	205	201	198	195	209

SENECA RIVER AT BALDWINSVILLE, NEW YORK.

his stream has its source in the lake of the same name in central r York; its general course is northeasterly until its junction with Oneida River in Onondaga County, where the two form the Oswego er, which flows northwesterly, entering Lake Ontario at the city of ego. The station is located at the dam on Seneca River at Baldsville, where the drainage area is 3,103 square miles. A head or t gage is placed at each end of the dam and both are read twice y. Only one tailrace gage was placed. The elevation of the zeros he crest gages is 93.99 feet, while the elevation of the zero of the ace gage is 84.91 feet, or a difference of 9.08 feet. To obtain the tive heads on the water wheels it is necessary to add to the daily lings of the crest gages 9.08 feet, and subtract the readings of the ace gage. Ten mills utilize the flow here developed for power poses, and to get the entire flow of the river it is necessary to keep cord of the different heads on the wheel gates as well as the unt of opening of each. The records at this point, as well as on ous other streams in the State of New York, were begun by Mr. rge W. Rafter for the United States Board of Engineers on Deep terways. The computations of discharge are quite laborious and e been made as noted in Volume XXVI of the Proceedings of the erican Society of Civil Engineers, page 308. The following figures based on Bazin's experiments. The Oswego Canal is fed from eca River, and *practically* its entire flow should be added to that

of the stream to obtain the total yield of the watershed. The discharge of this canal, including both lockage and leakage, was taken as 70 second-feet from June to October, 1899.

Estimated daily discharge, in second-feet, of Seneca River at Baldwinsville, New York, for 1898.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1	.....	2,528	10	.....	2,389	19	3,308	2,151	28	3,119	3,449
2	.....	2,512	11	.....	1,872	20	2,590	2,292	29	2,810	3,191
3	.....	2,609	12	3,011	2,219	21	3,293	2,418	30	2,801	3,326
4	.....	2,379	13	2,625	2,078	22	3,174	2,927	31	.....	3,365
5	.....	2,889	14	3,583	2,056	23	3,234	3,455	Mean	3,142	2,689
6	.....	2,715	15	3,684	1,982	24	*3,236	3,838			
7	.....	2,981	16	3,500	2,111	25	3,257	3,661			
8	.....	2,687	17	3,418	2,271	26	3,245	3,633			
9	.....	2,467	18	3,270	1,551	27	2,452	3,368			

Estimated daily discharge, in second-feet, of Seneca River at Baldwinsville, New York, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2,630	1,838	3,232	4,599	3,406	2,073	1,067	585	570	134	1,328	1,415
2	2,686	1,791	3,172	4,495	3,521	1,692	156	572	630	658	1,386	1,454
3	2,454	1,953	3,352	4,606	3,230	1,132	771	560	112	650	1,220	1,650
4	2,547	1,794	3,249	4,567	3,032	1,884	163	540	650	608	1,592	1,631
5	2,993	1,835	3,468	4,520	3,007	2,085	1,141	532	505	613	1,270	1,496
6	3,202	1,793	3,855	4,329	2,906	2,058	1,185	70	670	610	1,793	1,450
7	2,977	1,676	4,190	4,072	2,692	1,859	1,142	621	671	653	1,543	1,435
8	2,543	1,653	3,992	4,509	2,799	1,467	825	533	591	70	1,462	1,330
9	2,779	1,293	3,943	4,394	2,842	1,713	678	532	623	635	1,516	1,650
10	2,696	1,267	3,838	5,019	2,705	2,038	1,103	499	158	550	1,597	1,306
11	2,645	1,267	3,783	4,955	2,602	834	1,188	475	521	525	1,631	1,742
12	2,554	1,241	3,623	5,347	2,614	1,631	1,215	491	490	624	1,708	1,739
13	2,535	1,340	3,915	5,181	2,637	1,541	1,258	74	422	646	1,786	1,828
14	2,577	1,419	3,860	5,218	2,302	1,526	1,182	339	409	629	1,527	1,724
15	2,950	1,380	3,860	5,327	2,477	1,608	1,207	575	437	74	1,544	1,501
16	3,186	1,101	3,978	4,874	2,398	1,581	174	521	513	787	1,545	1,533
17	3,628	1,226	3,872	4,939	2,534	1,797	1,226	99	70	765	1,599	1,565
18	3,708	1,502	3,678	5,033	2,355	789	1,155	571	514	765	1,518	1,565
19	3,769	1,652	3,413	4,981	2,415	1,303	922	545	508	765	1,742	1,878
20	3,645	1,494	3,821	4,791	2,536	569	574	70	623	781	1,966	1,470
21	3,469	1,685	3,625	4,606	2,302	583	712	580	488	834	1,712	1,960
22	3,272	2,056	3,563	4,620	2,576	646	543	596	397	301	1,670	2,096
23	3,298	2,403	3,755	4,040	2,300	756	206	614	177	875	1,739	2,045
24	3,310	2,488	4,021	4,311	2,257	895	656	502	562	798	1,757	2,050
25	3,209	2,646	4,091	4,026	2,334	386	585	548	573	787	1,904	2,050
26	3,095	2,482	4,093	3,992	2,296	668	593	529	561	725	1,891	2,055
27	2,358	2,668	4,348	3,883	2,209	625	613	70	643	794	1,879	1,978
28	2,093	2,584	4,278	3,975	1,962	588	586	555	643	822	1,711	2,039
29	1,662	.....	4,776	3,853	2,045	543	531	522	691	351	1,728	2,091
30	2,028	.....	4,702	3,216	2,066	328	238	395	.....	947	1,087	2,089
31	1,871	.....	4,782	.....	2,192	.....	467	375	.....	971	.....	2,089
Mean	2,851	1,769	3,875	4,543	2,568	1,573	776	455	481	637	1,612	1,722

CHITTENANGO CREEK AT BRIDGEPORT, NEW YORK.

This creek rises in Madison County, New York, and flows in a northerly direction between Madison and Onondaga counties into Oneida Lake, the outlet of which is Oneida River, a tributary of Oswego River. The basin of Chittenango Creek is shown on Chittenango atlas sheet of the United States Geological Survey. Observations for the computation of flow of this creek are made at the mill dam in Bridgeport, New York, a short distance above its mouth. The drainage area at this point is 307 square miles. Three times a day observations are made of the river height above the crest of

ım, head on wheels, and the amount of gate opening. Jefferson .s, of the flour mill, is the observer. The mill runs three Cam- ırbines—two of which are 60-inch, and one 54-inch. The dam is ıber, backed with stone. The elevation of the zero of the crest is 92.84 feet, while the zero of the tailrace gage is 85.88 feet, the ence between them being 6.96 feet. In computing the flow over ım the crest is divided into three parts, each of which is con- ɜd as a separate weir. The discharge over the dam was first com- . from Bazin's experiments, but after July 1, 1899, it was com- . from the results of the experiments made at Cornell University. ɜss section of the dam and additional facts are given by Mr. W. Rafter in Volume XXVI of the Proceedings of the American :y of Civil Engineers, page 309.

ıted daily discharge, in second-feet, of Chittenango Creek at Bridgeport, New York, for 1898.

Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
.....	180	562	427	12...	.....	196	1,571	434	23...	115	465	593	1,203
.....	205	559	360	13...	.....	197	1,265	454	24...	135	487	569	1,401
.....	171	434	348	14...	.....	181	921	442	25...	85	472	490	1,075
.....	172	358	385	15...	.....	354	790	450	26...	142	352	442	857
.....	156	379	471	16...	82	335	694	472	27...	149	867	465	726
.....	309	385	414	17...	116	299	615	619	28...	214	972	523	541
.....	235	331	404	18...	53	284	500	605	29...	154	661	413	480
.....	204	359	320	19...	119	297	506	678	30...	198	565	421	630
.....	130	386	261	20...	139	320	675	669	31...	.....	519	.....	630
.....	165	474	265	21...	117	269	728	793					
.....	194	1,339	465	22...	111	463	623	1,155	Mean	129	344	612	597

ıted daily discharge, in second-feet, of Chittenango Creek at Bridgeport, New York, for 1899.

·.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
....	515	520	632	837	447	426	116	84	81	75	60	113
....	571	484	473	795	357	346	55	79	49	90	145	127
....	636	440	385	752	310	234	97	169	45	91	145	143
....	737	465	520	861	172	105	113	126	133	90	160	159
....	1067	385	1290	866	172	184	132	134	81	80	165	149
....	1310	356	1331	864	157	229	99	70	76	141	228	151
....	1282	342	1475	857	95	229	123	125	74	89	128	166
....	1135	465	1069	1420	172	244	132	125	96	45	120	179
....	724	385	860	1675	172	192	45	134	96	107	108	155
....	486	385	852	1369	227	147	89	79	15	117	65	168
....	473	385	659	1306	237	70	262	62	71	101	46	181
....	623	395	565	1274	172	169	271	44	96	101	35	211
....	849	538	1196	1597	172	192	162	15	92	85	72	326
....	738	524	1061	1737	165	182	169	141	56	72	57	395
....	1260	462	970	1614	180	100	99	125	58	15	65	395
....	1280	362	665	1405	174	184	70	103	79	84	60	374
....	1101	449	634	1339	250	192	101	87	25	30	88	355
....	632	354	526	1221	310	70	221	76	89	38	57	466
....	390	385	565	859	374	152	210	91	74	38	25	706
....	395	541	736	861	374	84	204	25	96	45	83	588
....	389	444	796	629	385	92	152	120	117	47	70	298
....	385	619	962	447	281	100	117	109	39	15	78	304
....	399	950	1061	165	265	124	70	96	84	60	100	254
....	372	1074	1345	627	252	134	102	(a)	25	68	102	200
....	311	1314	1061	527	197	70	102	.....	67	43	110	139
....	362	1015	885	456	195	141	122	.....	49	57	25	228
....	308	645	626	331	227	109	110	.....	112	48	109	261
....	332	755	760	279	225	109	88	.....	119	25	133	201
....	385	.....	1075	359	312	84	109	56	96	20	114	249
....	448	.....	1360	295	333	91	45	96	79	65	105	244
....	637	.....	1390	.....	229	.....	141	112	.....	65	.....	240
an.	662	551	893	921	245	161	123	96	76	64	95	281

a Repairing dam; water drawn off August 25 to 28.

ONEIDA CREEK AT KENWOOD, NEW YORK.

This stream rises in Madison County, New York, and flows in a northwesterly direction, crossing the Erie Canal and emptying into Oneida Lake at its southeastern extremity. It is shown on the Oneida atlas sheet of the United States Geological Survey. The station is located at the silk-mill dam in Kenwood, about 3 miles from Oneida, the drainage area at this point being 59 square miles. One gage gives the height of water above the crest of the dam, and two gages are read at the silk mill, giving the head on wheels. From these readings and from the number of gate openings the quantity of water passing over the dam as well as through the wheels is determined, thus giving the discharge of the creek at this point. The dam is of timber, well constructed, and without leakage. Computations of the flow over it have been made from Bazin's experiments of 1894. The computations for the discharge measurements after July 1, 1899, are based on the coefficients determined at Cornell University. The cross section of the dam is shown in Volume XXVI of the Proceedings of the American Society of Civil Engineers, page 309.

Estimated daily discharge, in second-feet, of Oneida Creek at Kenwood, New York, for 1899.

Day.	May.	June.	July.	Oct.	Nov.	Dec.	Day.	May.	June.	July.	Oct.	Nov.	Dec.
1	71	46	18	15	144	23	18	68	30	28	25	32	130
2	60	36	20	21	69	29	19	66	26	26	24	25	97
3	60	36	20	21	56	25	20	91	31	26	24	28	79
4	59	35	20	21	66	27	21	80	26	24	25	24	82
5	54	31	30	21	55	29	22	82	26	25	.....	26	80
6	55	31	34	21	44	29	23	63	31	10	25	24	68
7	48	31	21	24	40	25	24	54	31	26	25	26	55
8	53	24	41	.....	26	33	25	66	31	21	24	24	70
9	53	24	40	24	26	41	26	43	31	21	25	25	36
10	53	24	51	24	24	125	27	43	31	20	24	26	39
11	54	25	26	21	26	97	28	71	24	21	25	26	35
12	59	26	24	24	27	70	29	108	24	18	.....	26	34
13	59	26	24	24	28	70	30	76	21	10	29	26	35
14	48	26	24	24	26	91	31	59	.....	21	31	.....	34
15	53	51	21	.....	22	82							
16	60	41	20	25	26	73	Mean	62	30	25	24	31	69
17	61	36	31	25	26	130							

Record not kept for August and September.

WEST BRANCH OF FISH CREEK AT McCONNELLSVILLE, NEW YORK.

This stream rises in the northern part of Oneida County and flows in a southerly direction to its junction with the East Branch, where it forms the main Fish Creek, which stream flows in a westerly direction, emptying into the east end of Oneida Lake. The lower part of the course of Fish Creek is shown on the Oneida atlas sheet of the United States Geological Survey. The station is located at the Harden dam in McConnellsville. The drainage area at this point is 186.7 square miles. The dam is of timber, with a small leakage. The crest has been so repaired by the Board on Deep Waterways that it is horizontal. The record of gage heights is voluntarily kept by

Frank S. Harden, on a gage showing the height of the river above the crest of the dam and also on one at the end of the tailrace. The flow of this dam is computed from Bazin's experiments, series 170, up to July 1, 1899, and after that date they are based on the experiments made at Cornell University, as noted in Volume XXVI of the Proceedings of the American Society of Civil Engineers, page 310.

Estimated daily discharge, in second-feet, of West Branch of Fish Creek at McConnellsville, New York, for 1898.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	137	365	237	12		.....	87	997	199	23	57	700	216	317
2	50	319	245	13		100	124	700	186	24	332	750	300	468
3	111	292	217	14		90	134	734	212	25	360	624	329	390
4	121	172	195	15		96	307	434	162	26	197	434	319	285
5	130	155	182	16		47	360	514	157	27	231	1,097	255	285
6	137	120	182	17		47	562	365	147	28	181	871	299	225
7	131	146	196	18		50	346	365	120	29	181	686	251	170
8	122	138	182	19		98	227	365	187	30	147	440	172	120
9	65	135	199	20		81	190	370	157	31	.....	464	.....	120
10	102	557	180	21		57	172	371	190					
11	81	1,562	140	22		55	467	220	287	Mean	134	333	384	210

Estimated daily discharge, in second-feet, of West Branch of Fish Creek at McConnellsville, New York, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	Day.	Jan.	Feb.	Mar.	Apr.	May.
1	120	228	402	586	273	18	615	133	567	1644	189
2	126	183	402	520	313	19	615	120	485	1434	374
3	194	183	438	601	243	20	530	183	505	1174	374
4	261	172	595	601	184	21	495	198	433	1085	255
5	321	120	700	601	184	22	360	258	442	1045	308
6	396	212	956	591	184	23	314	338	443	940	244
7	396	156	856	689	120	24	425	438	442	664	194
8	285	156	700	1557	183	25	350	438	442	564	189
9	352	147	856	2110	154	26	325	360	360	470	174
10	422	136	583	1690	154	27	338	403	552	366	134
11	502	117	546	1724	183	28	308	403	599	366	50
12	587	80	700	2055	243	29	225	.....	599	364	700
13	873	99	1178	2440	194	30	278	.....	599	220	455
14	873	132	1178	2920	120	31	278	.....	599	.....	483
15	796	94	1178	3040	189						
16	787	131	972	2410	189	Mean	435	206	615	1,206	230
17	735	148	782	1720	189						

EAST BRANCH OF FISH CREEK ABOVE POINT ROCK, NEW YORK.

This stream rises in Lewis County, New York, and flows in a southerly direction into Oneida County, where it joins the West Branch to form the main Fish Creek. The station is located at the sawmill of Fowler W. Willson at Point Rock. The dam is of timber and has considerable leakage. The old sawmill located here is seldom used; whenever the wheels are running, however, record is kept of the length of time and of the amount of gate openings. The profile of crest of dam is somewhat irregular and, in order to facilitate computations, has been divided into five sections, the flow through each of which has been computed separately by Bazin's experiments of 1894. The discharge measurements after July 1, 1899, are based on experiments made at

Cornell University, as noted in Volume XXVI of the Proceedings of the American Society of Civil Engineers, page 310.

Estimated daily discharge, in second-feet, of East Branch of Fish Creek at Point Rock, New York, for 1898.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	.....	160	340	325	12	.....	225	820	360	23	155	1,090	370	660
2	.....	100	320	325	13	.....	250	485	340	24	690	710	370	745
3	.....	100	250	360	14	.....	295	450	385	25	420	460	345	880
4	.....	80	245	340	15	.....	600	395	335	26	300	450	325	850
5	.....	210	210	340	16	.....	555	370	510	27	265	1,245	325	895
6	.....	295	385	340	17	.....	350	310	520	28	370	710	340	630
7	.....	240	415	345	18	.....	250	340	520	29	300	490	385	490
8	.....	210	350	360	19	.....	230	345	570	30	160	400	370	610
9	.....	185	400	370	20	.....	310	340	600	31	.....	370	.....	610
10	.....	185	720	350	21	.....	240	310	630					
11	.....	170	1830	360	22	10	860	265	685	Mean.	296	387	424	501

Estimated daily discharge, in second-feet, of East Branch of Fish Creek at Point Rock, New York, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	565	475	748	970	2,745	305	(a)	(a)	(a)	25	650	1,200
2	670	475	810	1,040	2,260	390	.....	.....	.....	21	650	1,250
3	670	420	810	1,090	1,950	270	.....	.....	.....	27	665	1,180
4	805	450	815	1,150	1,340	265	.....	.....	.....	35	660	1,160
5	1,190	420	840	1,420	930	295	.....	.....	.....	40	635	1,120
6	1,280	450	900	1,435	750	295	.....	.....	.....	60	680	1,120
7	1,280	390	1,010	1,330	660	260	.....	.....	.....	68	700	1,040
8	1,090	370	1,010	1,220	635	230	.....	.....	.....	80	710	1,000
9	1,060	420	770	1,150	540	200	.....	.....	.....	100	750	1,060
10	985	390	945	1,240	520	160	.....	.....	.....	110	790	1,000
11	930	370	1,150	1,390	510	150	.....	.....	.....	110	825	1,040
12	900	320	1,245	1,500	520	165	.....	.....	.....	120	840	1,180
13	1,005	440	1,200	1,600	570	150	.....	.....	.....	115	825	1,180
14	1,000	420	1,110	1,660	520	140	.....	.....	.....	120	840	1,040
15	770	500	1,045	1,760	580	130	.....	.....	.....	150	880	1,000
16	680	610	985	1,870	510	125	.....	.....	.....	130	860	990
17	610	640	985	1,900	500	115	.....	.....	.....	180	860	965
18	485	740	1,090	1,900	600	125	.....	.....	.....	190	880	990
19	550	760	1,150	2,030	650	150	.....	.....	.....	190	900	1,000
20	510	810	1,100	2,510	700	170	.....	.....	.....	190	900	990
21	490	750	1,060	3,170	635	175	.....	.....	.....	195	840	965
22	485	780	1,045	3,550	540	175	.....	.....	.....	220	840	915
23	425	820	1,165	4,030	410	170	.....	.....	.....	270	860	915
24	385	825	1,165	4,320	415	150	.....	.....	.....	270	900	880
25	370	900	1,235	4,650	500	120	.....	.....	.....	285	920	810
26	350	945	1,235	4,170	450	105	.....	.....	.....	290	900	960
27	320	1,050	1,165	3,490	410	95	.....	.....	.....	335	940	960
28	370	1,210	1,150	3,110	440	100	.....	.....	.....	415	1,025	1,040
29	320	.....	1,130	2,790	475	80	.....	.....	.....	510	1,080	1,045
30	320	.....	1,200	2,790	450	70	.....	.....	.....	530	1,100	1,060
31	340	.....	1,245	.....	400	.....	.....	.....	.....	620	.....	1,060
Mean.	684	612	1,049	2,208	745	177	.....	.....	.....	194	830	1,035

a Flow during July, August, and September not computed, owing to fact that all water leaked through the dam.

OSWEGO RIVER AT FULTON, NEW YORK.

This stream is formed by the junction of Oneida and Seneca rivers in Onondaga County, New York, and flows northwesterly, emptying into Lake Ontario at the city of Oswego. The station is located at the dam at Fulton, 7 miles above Oswego, the catchment area being 4,916 square miles. The dam is well built of stone and brick and has *no leakage*. At this point four gages are read—one above the dam,

ıe in the tailrace of the Fulton Worsted Mill, one in the headrace ıd one in the tailrace of the Oswego Falls Pulp and Paper Comıny's mill. The mills are located at each end of the dam, and both ıe water from the Oswego River. The dam is 404.6 feet in length, ıd the crest is practically level. During the low-water stages flashɔards are placed on the crest of the dam, and in order to compute ıe discharge of the river at this point it is necessary to take these ashboards into account, as well as the height of the dam, the head ı the various wheels, and the number of openings of the same. The ɔcords at this point are not at present available. A cross section of ıe dam is given in Volume XXVI of the Proceedings of the American ociety of Civil Engineers, page 309.

OSWEGO RIVER AT OSWEGO, NEW YORK.

Another series of records on this stream besides the one at Fulton have been maintained at the high dam between Oswego and Fulton. The water at this point is used in the State canal and by the Oswego Waterworks Company, whose pump house is on the left side of the stream. This station was established April 1, 1897. The following figures of daily gage height were obtained from Mr. Thomas H. Bennett, superintendent of the Oswego Waterworks Company:

Daily gage height, in feet, of Oswego River at Oswego, New York, for 1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.38	.....	5.63	6.56	8.08	8.79	8.33	8.50	7.42
2	3.54	4.58	5.60	6.33	8.08	.....	8.38	8.29	7.42
3	3.71	4.65	5.60	6.42	.....	8.79	.....	8.17	7.33
4	.....	4.73	5.60	.....	8.08	8.83	8.67	8.17	7.44
5	3.71	4.75	.....	6.42	8.17	.....	8.46	8.25	.....
6	3.71	4.83	5.63	6.46	.....	8.92	8.42	8.17	7.08
7	3.71	4.88	5.63	6.58	8.25	8.79	8.42	.....	7.17
8	3.75	.....	5.67	6.79	.....	8.83	8.54	8.21	7.17
9	3.52	4.94	5.67	6.75	8.58	8.75	8.58	8.17	6.88
10	.....	5.00	5.67	6.79	8.50	8.83	.....	8.08	6.83
11	3.54	5.00	5.67	.....	8.50	8.83	8.46	8.17	6.75
12	3.54	.....	.....	6.50	8.42	.....	8.46	8.17	.....
13	3.54	5.04	5.67	6.83	8.50	8.42	8.54	8.25	6.79
14	3.71	5.08	5.75	6.96	8.44	8.29	8.33	8.25	6.83
15	3.71	.....	5.75	6.83	.....	8.38	8.42	.....	6.50
16	3.75	5.04	5.77	6.75	8.58	8.33	8.38	8.04	6.54
17	.....	5.04	5.85	6.75	8.42	8.50	.....	7.98	6.50
18	3.90	5.04	5.90	.....	8.42	8.54	8.79	7.92	6.50
19	4.00	5.17	.....	6.67	8.50	.....	8.42	7.83	.....
20	4.08	5.25	5.96	6.71	8.50	8.67	8.25	7.83	6.50
21	4.13	5.25	6.17	6.67	8.54	8.63	.....	.....	6.63
22	4.17	.....	6.17	6.75	.....	8.58	8.33	7.79	6.75
23	4.21	5.29	6.25	6.71	8.67	8.58	8.33	7.92	6.75
24	4.27	5.38	6.25	6.83	8.71	8.58	.....	7.79	7.17
25	4.48	5.29	6.33	.....	8.71	8.42	8.38	7.79	7.33
26	4.48	5.38	.....	6.42	8.75	.....	8.42	7.79	.....
27	4.48	5.42	6.25	6.33	8.75	8.50	8.46	7.46	7.08
28	4.48	5.42	6.38	6.33	8.75	8.21	8.42	.....	7.25
29	4.50	.....	6.21	a 8.00	.....	8.54	8.50	7.17	7.46
30	4.67	5.46	6.31	8.13	8.79	8.46	8.50	7.17	7.17
31	.....	5.46	.....	8.10	8.58	.....	.....	.....	7.25

a 2.01 feet were added to the wall of the dam.

Daily gage height, in feet, of Oswego River at Oswego, New York, for 1898.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.58	6.50	5.88	6.13	.....	7.00	8.29	8.33	7.83	.....	7.00	6.75
2	.....	6.50	5.92	6.17	6.46	.....	8.29	8.33	7.83	7.83	7.00	6.75
3	7.42	6.50	6.00	.....	6.50	6.96	.....	8.33	7.88	.....	7.00	.....
4	7.58	6.67	6.08	6.31	6.29	7.25	.....	8.00	8.17	7.83	7.00	6.40
5	7.29	6.67	6.17	6.35	6.27	7.25	.....	8.17	7.92	7.88	.....	6.75
6	7.46	.....	.....	6.44	6.25	7.25	.....	8.25	7.96	.....	7.08	6.92
7	7.25	6.50	6.29	6.50	6.21	7.25	7.83	8.25	7.96	7.92	7.02	6.75
8	7.33	6.67	6.25	6.58	.....	7.50	.....	8.08	7.67	.....	7.08	6.96
9	.....	6.63	6.25	6.67	6.21	7.50	.....	8.25	7.71	7.88	7.00	7.04
10	7.50	6.63	6.25	.....	6.25	7.58	8.00	8.25	7.67	7.96	6.42	.....
11	7.50	6.63	6.21	6.71	6.33	7.58	8.00	8.33	7.83	8.00	6.38	7.00
12	7.33	6.17	6.13	6.83	.....	7.58	7.92	8.42	7.75	8.00	.....	7.00
13	6.75	.....	.....	6.92	6.42	7.67	7.58	8.50	7.67	8.25	6.08	7.42
14	6.63	6.54	5.92	6.92	6.42	7.75	7.58	8.21	7.83	.....	6.08	7.50
15	6.50	6.63	5.88	7.00	6.46	7.77	.....	8.42	7.92	.....	6.17	7.33
16	.....	6.83	5.88	7.00	.....	.....	.....	8.25	7.92	7.67	6.25	7.25
17	6.25	6.58	5.85	.....	.....	7.90	.....	8.25	7.67	7.75	6.25	.....
18	6.54	6.00	5.88	7.10	6.71	7.90	.....	8.25	8.00	7.67	6.33	7.17
19	6.54	6.00	5.88	7.17	6.71	8.00	.....	8.25	8.00	7.67	.....	7.25
20	6.54	.....	.....	6.92	.....	8.00	.....	8.25	8.00	7.58	6.33	7.17
21	6.29	5.92	5.88	7.13	.....	8.00	.....	8.33	8.00	7.58	6.33	6.75
22	6.21	5.92	5.83	7.17	.....	8.08	.....	8.21	8.00	.....	6.25	6.50
23	.....	5.79	5.83	7.17	6.83	8.08	.....	8.25	8.00	7.33	6.38	6.13
24	5.75	5.67	5.88	.....	.....	8.13	.....	8.33	7.92	7.17	6.42	.....
25	5.75	5.67	5.88	6.50	.....	.....	.....	8.27	7.88	7.17	6.42	6.08
26	5.88	5.67	5.92	6.38	6.92	.....	.....	7.83	8.08	7.13	.....	6.08
27	5.83	.....	.....	6.25	.....	.....	.....	7.92	7.92	7.08	6.50	6.13
28	6.17	5.75	6.00	6.17	.....	8.21	.....	7.92	8.00	6.96	6.50	6.42
29	6.17	.....	6.00	6.27	.....	8.27	.....	7.92	7.92	7.00	6.58	6.25
30	.....	.....	6.04	6.29	.....	8.29	.....	7.75	7.88	.....	6.58	6.25
31	6.83	.....	6.04	.....	6.96	.....	.....	7.75	.....	7.00	.....	.....

Daily gage height, in feet, of Oswego River at Oswego, New York, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	6.54	7.21	6.83	5.92	6.08	7.33	.....	8.42	8.29	8.50	7.92
2	6.71	7.29	6.75	.....	6.08	7.33	8.00	8.33	.....	8.33	7.92
3	6.54	7.21	6.67	5.83	6.08	.....	.....	8.33	9.00	8.33	7.75
4	6.29	.....	6.67	5.83	.....	7.67	8.00	8.33	8.42	8.42	.....
5	.....	7.38	6.33	5.83	6.33	7.67	8.00	.....	8.50	8.42	7.75
6	6.25	7.38	8.25	5.83	.....	7.83	8.17	8.33	8.58	8.42	7.67
7	6.46	7.42	6.25	5.92	6.83	7.83	8.33	8.33	8.33	.....	7.75
8	6.67	8.08	6.42	.....	6.50	8.00	.....	8.50	8.50	.....	.....
9	7.00	8.67	6.50	5.25	6.67	8.17	8.00	8.33	.....	8.50	.....
10	7.08	8.50	6.50	5.33	6.83	.....	8.08	8.42	7.08	8.50	.....
11	7.00	.....	.....	5.25	6.83	8.08	8.00	8.33	8.58	8.50	.....
12	7.00	7.75	6.33	5.17	.....	8.08	8.17	.....	9.00	8.50	.....
13	6.75	7.75	6.33	5.17	.....	8.25	8.17	8.42	8.55	8.67	.....
14	.....	7.58	6.42	5.21	7.08	7.50	8.33	8.50	8.33	8.58	.....
15	6.17	7.38	6.38	.....	7.08	7.50	.....	8.42	8.75	.....	.....
16	6.13	7.25	6.33	5.25	7.00	7.50	8.08	8.33	10.58	8.58	.....
17	6.13	7.33	6.38	5.25	7.00	.....	8.25	8.33	.....	8.67	.....
18	6.25	.....	.....	5.25	7.00	7.50	8.33	9.08	.....	8.42	.....
19	6.29	7.33	6.50	5.33	7.08	7.58	8.33	.....	8.67	8.75	.....
20	6.25	7.21	6.50	5.25	.....	7.58	8.33	9.50	8.50	8.50	.....
21	.....	7.17	6.46	5.50	7.08	7.67	8.42	8.50	9.17	.....	.....
22	6.42	7.00	.....	.....	7.08	7.67	.....	8.33	8.67	8.33	.....
23	6.42	7.00	6.33	5.54	7.08	7.83	8.33	8.42	.....	8.33	.....
24	6.50	7.00	6.38	5.63	7.08	.....	8.33	8.50	9.33	8.33	.....
25	6.33	.....	.....	5.75	7.25	7.67	8.42	8.42	8.50	8.42	.....
26	6.29	6.75	6.13	5.75	7.33	7.50	.....	8.42	8.50	8.50	.....
27	7.42	6.79	6.13	5.79	.....	7.67	8.33	8.50	8.50	8.33	.....
28	7.08	6.79	6.17	5.75	7.33	.....	8.42	8.50	8.50	.....	.....
29	7.42	.....	5.83	.....	7.33	8.17	.....	8.00	8.50	8.08	.....
30	7.25	.....	5.75	6.00	7.33	8.25	8.42	8.17	.....	8.33	.....
31	7.25	.....	5.75	.....	7.33	.....	8.42	8.33	.....	8.33	.....

SALMON RIVER AT ORWELL, NEW YORK.

This river rises in Lewis County, New York, and flows in a westerly direction into Lake Ontario, a portion of its course being shown on the Pulaski atlas sheet of the United States Geological Survey. At a point about a mile below Orwell are Salmon Falls, where the river has a vertical descent of about 110 feet, but at present no attempt

been made to utilize it. Observations were made at Orwell, at :h locality the river has a drainage area of 190.5 square miles. gages are at an old wooden dam built to furnish power for a saw- . The dam is considerably out of repair and leaks badly. When station was first established current-meter measurements were e of this leakage, and it was found to be 88 cubic feet per second. profile of the crest is irregular, and in order to facilitate computa- is divided into four parts, each section being computed separately the sum total taken as the entire flow. The station was aban- ɔd May 31, 1899, on account of the leakage through the dam, which as difficult to estimate accurately. The results are not at present lable for publication.

BLACK RIVER AT WATERTOWN, NEW YORK.

his river rises in Herkimer County and flows in a northeasterly ction into Black River Bay, an arm of Lake Ontario. A portion ts course is shown on the Watertown atlas sheet of the United es Geological Survey. Observations of the height of water have ı made at the dam of the city waterworks of Watertown, located iles above, at Huntingtonville. The station was established on ruary 22, 1897. The record in the following table has been fur- ıed by Frank A. Hinds, civil engineer. It is the average of two y readings.

he readings from August 22 to September 16, 1897, do not give reli- : data, as the high dam on the opposite channel of the river devel- d a leak, which gradually increased until it became necessary to n the traps in the dam, letting the water down so that it could be aired. It is possible that this leak commenced earlier than August The conditions at this point are peculiar, in that the stream flows two channels with an island between. There is a dam on each nnel, the high dam, previously referred to, creating a settling in for the water supply of the city of Watertown. The other dam, ɔwn as the Huntingtonville, on the opposite side of the island, is one near which the readings given herewith are taken.

n addition to the amount of water which is indicated by the flow over ı (the Huntingtonville) dam, there should be added the quantity en from the other channel above the high dam to supply water for city of Watertown. There is also constant leakage from seams in rock underneath the Huntingtonville dam, where the observations made. This quantity has been variously estimated, but direct ısurements have not been made. In the following table the original lings have been diminished by dropping the figure 100; for example, reading on February 22, 1897, of 103.10 is given below as 3.10. In a instances this has introduced a minus quantity when the surface pped below 100, as was the case on October 3, and 8 to 11, 1897.

'he crest of the dam is irregular in profile, and for ease of computa- ı is divided *into six parts*, each of these being considered horizontal.

The discharge of the river was computed by Mr. Robert E. Horton. The results, however, have been revised several times upon the acquisition of new information. Another record of Black River has been kept by the Taggart Company at Felts Mills, about 10 miles above Watertown, covering a somewhat longer period of time than that at Huntingtonville, but the figures are not at present available.

Daily gage height, in feet, of Black River at Huntingtonville dam, for 1897.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.00	4.20	5.01	3.73	2.89	3.20	1.28	0.35	2.68	4.63
2	.....	.....	4.23	4.83	3.58	2.88	3.16	.95	.37	2.84	4.40
3	.....	.....	4.40	4.56	3.40	2.93	3.15	1.26	.02	3.21	3.57
4	.....	.....	4.48	4.41	3.57	2.85	3.03	1.44	.10	3.50	3.45
5	.....	3.32	4.90	4.58	3.72	2.79	2.85	1.14	.18	3.42	3.75
6	.....	3.58	5.03	4.49	3.65	2.71	2.79	1.55	.10	3.25	4.10
7	.....	3.69	5.22	4.43	3.49	2.93	2.70	1.65	.03	3.20	4.26
8	.....	3.74	5.48	4.12	3.40	2.75	2.49	1.55	.02	3.34	4.31
9	.....	3.80	5.60	3.83	3.30	2.73	2.64	1.49	.44	3.35	4.38
10	.....	3.98	5.60	3.59	4.05	2.77	2.70	1.47	.63	3.56	4.40
11	.....	4.35	5.40	3.59	4.48	2.64	3.60	1.23	.10	4.02	4.77
12	.....	4.43	5.05	3.45	4.54	2.67	4.63	.78	.35	4.03	4.83
13	.....	4.58	4.75	3.47	4.43	2.82	4.74	.71	1.68	4.15	4.70
14	.....	4.50	4.64	3.63	4.03	2.69	4.40	.80	2.92	3.92	4.60
15	.....	4.35	4.70	4.08	3.73	2.95	3.75	.35	3.00	3.82	4.73
16	.....	4.20	4.88	4.23	3.55	2.99	3.42	.00	3.45	3.63	4.91
17	.....	4.00	5.07	4.10	3.44	2.95	3.23	1.25	2.83	3.95	5.00
18	.....	3.90	5.15	3.95	3.31	2.90	3.30	1.40	2.98	4.23	4.96
19	.....	3.88	5.24	3.72	3.18	2.87	3.44	1.08	2.95	4.24	4.46
20	.....	4.38	5.18	3.64	3.10	2.89	3.23	1.28	2.88	3.90	3.75
21	.....	5.20	5.24	3.46	3.33	2.90	3.03	1.18	2.83	3.60	3.68
22	3.10	5.10	5.16	3.51	3.53	2.85	2.91	1.33	2.80	3.73	3.68
23	3.10	5.48	4.95	3.65	3.39	2.76	2.89	1.38	2.79	3.57	3.66
24	3.50	6.48	4.82	3.44	3.23	2.70	2.74	1.25	2.60	3.35	3.50
25	3.25	6.10	5.13	3.47	3.07	2.60	2.63	1.25	2.88	3.25	3.43
26	3.75	5.70	5.53	3.90	2.99	2.90	2.66	1.30	2.77	3.74	3.47
27	.....	5.45	5.80	4.13	2.89	2.87	2.67	1.30	2.79	4.90	3.39
28	.....	4.88	6.07	4.03	2.99	2.85	2.44	1.65	2.83	5.13	3.36
29	.....	4.48	6.01	3.92	2.89	3.00	2.34	1.58	2.75	5.28	3.32
30	.....	4.30	5.41	3.85	2.87	3.28	1.97	.33	2.75	4.92	3.30
31	.....	4.30	.....	3.80	.....	3.30	.63	.....	2.73	.....	3.23

Daily gage height, in feet, of Black River at Huntingtonville dam, for 1898.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.21	3.55	3.40	4.75	4.03	3.55	3.09	2.95	3.01	3.14	3.65	3.48
2	3.39	3.60	3.50	4.59	3.73	3.42	3.04	3.15	3.00	2.91	3.53	3.45
3	3.28	3.57	3.40	4.20	3.78	3.31	2.84	2.96	2.95	2.94	3.50	3.45
4	3.30	3.50	3.40	3.90	3.83	3.23	2.80	3.03	2.45	2.95	3.43	3.38
5	3.34	3.55	3.35	3.80	3.89	3.21	2.95	3.10	3.05	3.08	3.40	3.40
6	3.30	3.45	3.35	3.80	4.13	3.14	2.94	3.26	3.22	3.55	3.37	3.38
7	3.25	3.50	3.35	3.75	4.03	3.13	2.98	3.20	3.19	3.70	3.65	3.28
8	3.15	3.50	3.37	3.73	3.75	3.05	2.91	3.15	3.20	3.58	3.60	3.23
9	3.25	3.45	3.52	3.65	3.55	2.98	2.88	3.01	3.28	3.27	3.60	3.18
10	3.23	3.40	3.75	3.63	3.60	3.01	2.76	2.95	3.23	3.28	3.60	3.19
11	3.23	3.68	4.53	3.63	3.45	3.11	2.82	2.95	3.10	3.19	4.98	3.13
12	3.22	4.65	5.75	3.56	3.28	3.03	2.90	2.98	3.11	3.06	5.15	3.23
13	3.63	4.93	6.75	3.51	3.80	3.05	2.90	3.05	3.03	3.03	5.13	3.23
14	4.00	4.75	7.50	3.53	3.86	3.23	2.80	3.02	2.88	3.16	5.05	3.25
15	4.10	4.55	8.10	3.60	3.72	3.35	2.90	2.70	2.90	3.53	4.78	3.25
16	4.04	4.30	7.55	3.59	3.51	3.31	2.90	3.01	2.85	3.77	4.48	3.26
17	3.99	4.05	6.70	3.48	3.50	3.23	2.88	2.90	2.84	4.03	4.08	3.30
18	3.88	3.90	6.20	3.38	3.42	3.13	2.90	2.85	2.62	3.85	3.88	3.25
19	3.78	3.80	6.00	3.48	3.35	2.97	3.09	2.88	2.80	3.62	3.70	3.28
20	3.75	3.73	5.74	3.58	3.48	3.25	2.97	2.87	2.81	3.53	3.61	3.33
21	4.00	3.85	5.83	3.85	3.58	3.35	3.00	2.88	2.96	3.52	3.71	3.33
22	4.35	3.91	5.97	3.99	3.53	3.30	3.00	2.81	2.92	3.61	3.71	3.48
23	4.35	3.89	5.87	4.25	3.44	3.23	3.00	2.95	2.85	4.02	3.63	3.98
24	4.48	3.80	5.55	4.53	3.48	3.18	2.87	3.35	3.10	4.31	3.71	4.34
25	4.43	3.69	5.18	4.73	3.55	3.05	3.03	3.50	3.54	4.08	3.56	4.30
26	4.32	3.60	4.95	5.09	3.58	3.00	3.30	3.65	3.58	3.93	3.48	4.22
27	4.12	3.55	4.65	5.33	3.85	2.93	3.20	3.66	3.55	4.33	3.18	4.00
28	3.90	3.65	4.48	5.24	3.93	3.05	3.05	3.53	3.43	4.60	3.31	3.75
29	3.74	.....	4.51	4.85	3.73	3.04	3.06	3.30	3.39	4.57	3.41	3.65
30	3.59	.....	4.75	4.40	3.69	3.03	3.03	3.10	3.25	4.25	3.50	3.83
31	3.60	.....	4.88	.....	3.66	.....	3.12	3.08	.....	3.90	.....	4.14

Daily gage height, in feet, of Black River at Huntingtonville dam, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.98	3.28	3.79	3.95	6.71	3.65	3.10	2.88	2.89	2.88	3.38	2.98
2	3.91	3.33	3.70	3.89	6.43	3.43	2.91	2.90	3.01	2.88	3.75	2.99
3	3.74	3.31	3.69	3.86	6.20	3.38	2.90	2.95	2.70	3.10	3.93	3.08
4	3.80	3.30	3.73	3.79	5.99	3.23	2.88	2.90	2.95	3.05	3.69	3.33
5	5.38	3.30	3.88	3.80	5.70	3.18	3.07	2.83	2.60	2.98	3.59	3.32
6	5.25	3.30	4.23	3.91	5.20	3.20	3.09	2.73	2.90	2.91	3.53	3.18
7	5.05	3.30	4.43	4.06	4.79	3.18	3.15	2.80	2.85	2.91	3.43	3.10
8	5.05	3.30	4.32	4.65	4.21	3.13	3.10	2.85	2.91	2.73	3.25	3.00
9	4.89	3.30	4.21	4.92	3.95	3.05	2.98	2.90	2.93	2.92	3.24	2.99
10	4.63	3.29	4.08	4.96	3.83	3.13	3.28	2.83	2.91	2.83	3.10	2.95
11	4.30	3.25	3.95	5.09	3.73	3.00	3.50	2.76	3.00	2.88	3.08	3.18
12	4.05	3.29	4.24	5.43	3.83	3.13	3.35	2.73	2.73	2.80	2.93	4.15
13	3.93	3.38	4.93	5.51	3.88	3.05	3.21	2.75	3.05	2.81	3.09	4.98
14	3.90	3.38	4.90	5.71	3.70	3.05	3.13	2.76	2.70	2.81	2.96	4.98
15	4.11	3.38	4.84	5.99	3.60	2.98	3.08	2.92	2.74	2.81	3.00	4.88
16	4.39	3.35	4.65	6.01	3.63	3.10	2.91	2.95	2.98	2.74	3.06	4.35
17	4.41	3.37	4.60	6.06	3.65	3.10	2.87	2.93	2.78	2.90	3.10	3.53
18	4.30	3.29	4.40	6.06	3.83	3.10	2.90	3.16	3.00	2.89	3.10	3.71
19	4.25	3.25	4.25	6.17	3.63	3.18	3.03	2.90	2.98	2.92	2.93	4.11
20	3.65	3.30	4.09	6.61	3.85	3.05	2.88	2.75	2.75	2.94	2.95	4.30
21	3.84	3.33	4.10	7.13	4.05	3.00	2.88	2.63	2.80	2.83	3.01	4.55
22	3.73	3.42	4.09	7.64	4.01	3.00	2.90	2.90	2.93	2.63	2.98	4.60
23	3.68	3.61	4.10	7.71	3.85	3.00	2.89	2.85	2.75	2.90	2.93	4.20
24	3.60	3.76	4.20	7.72	3.77	3.05	3.00	2.83	2.70	2.88	2.99	4.10
25	3.55	3.75	4.17	7.70	3.59	3.02	3.05	3.01	2.90	2.93	2.95	4.00
26	3.59	3.65	4.13	7.72	3.44	3.03	2.96	2.95	2.95	2.95	2.79	3.60
27	3.50	3.75	4.08	7.62	3.46	3.13	2.82	2.83	2.99	2.95	2.94	3.48
28	3.43	3.78	3.98	7.51	3.43	3.05	2.94	2.84	2.99	2.95	2.96	3.40
29	3.30	4.10	3.94	7.34	3.42	2.98	2.82	2.85	2.99	2.93	2.93	3.38
30	3.40	4.10	4.08	7.06	3.73	3.05	2.65	2.90	3.03	3.03	2.86	3.38
31	3.34	.....	3.97	.....	3.75	.....	2.68	2.88	.....	3.28	.....	3.23

ST. LAWRENCE RIVER NEAR MONTREAL, CANADA.

St. Lawrence River receives the outflow of the Great Lakes, and, discharging northeasterly, is joined by Ottawa River near the city of Montreal. About 50 miles below Montreal the river widens into what is known as Lake St. Peter. At the upper end of this lake is the town of Sorel; at which is one of the important gages for recording the height of the stream. The discharge of the river has been measured at a point about 40 miles below Montreal and a mile below the wharf at the town of Lanoraie, this place being chosen because of the excellent form of the channel. The width of the river here is between 3,000 and 3,300 feet, and the depth at low stages about 40 feet. The first measurement was made by Mr. W. J. Sproule, under the direction of the Montreal Flood Commission, by means of rod floats, on November 9 and 13, 1886. At that time the height of water was 11 feet 9 inches on the flats of Lake St. Peter. The area of cross section was 115,298 square feet, and the discharge 311,101 second-feet.[1] The next measurements were made by Prof. C. H. McLeod, of McGill University, Montreal, on November 13 and 14, 1895. At that time the water was 8 feet 9 inches in depth on the flats of Lake St. Peter, the area was 105,432 square feet, and the discharge 215,621 second-feet. The lowest water of that year (1895) occurred in the latter part of October and early in November, the water level being at the time of measurement 7 inches above the lowest

[1] Discharge of the St. Lawrence River, by Prof. C. H. McLeod: Trans. Can. Soc. Civil Engineers, Vol. X, Part I, 1896, p. 129.

point previously recorded. It is estimated that at the lowest stage of that year, which is the lowest on record, the cross section was reduced about 2 per cent, and the discharge was estimated to have been 196,000 second-feet.

On October 23 and 24, 1896, another measurement was made by Professor McLeod, giving an area of cross section of 117,500 square feet and a discharge of 258,500 second-feet. At this date the depth of water on the flats of Lake St. Peter was 10 feet and 7 inches. All depths on these flats have been obtained by reduction from the zero readings taken on the gage at Sorel, the zero of which is said to correspond to 9 feet 6 inches below the level of the flats, and to +0.05 on Steikel's datum, as noted in the Reports of the Public Works Department, Canada, for 1890–91. The height of water at this section is known to be influenced slightly by the tides, but the effect on the discharge has not been investigated.

The discharge of Ottawa River was measured on September 27 and 28, 1899, at a point about 2 miles below the dam at Carillon. The cross section measured 50,000 square feet and the discharge 39,600 second-feet. At the time of the measurement the reading of the gage at Lock No. 1 of Carillon Canal gave 12.0 feet on the lower sill.

MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA.

Measurements of discharge of the Mississippi River at St. Paul, below the mouth of the Minnesota River, have been made for a number of years by the Engineer Corps of the United States Army. The object of the measurements is the determination of the effect of the reservoirs at the head of the Mississippi River in maintaining deep or navigable water during the periods of drought. Measurements and computations of the amount of water discharged from reservoirs at such seasons are made and comparisons had with the behavior of the river at St. Paul and lower places. Observations of river height are made at the United States Weather Bureau gage located on a wharf near the foot of Jackson street. The zero of this gage is at an elevation of 683.334 feet. The measurements are made from a boat, at a section about halfway between Wabash street bridge and Roberts street bridge, in the city of St. Paul. Every time a series of observations are made two wires are stretched across the river parallel to each other and at a distance of 13 feet apart. Upon the completion of the measurement the wires are reeled up separately on apparatus especially constructed for the purpose, as it is impossible to maintain permanent cables across the river, on account of obstructing navigation. The bridges in the city are too high for satisfactory work. Records of height are maintained by the United States Weather Bureau and are furnished to this office. Results of measurements may be found as follows: 1897, Nineteenth Annual Report, Part IV, page 267; 1898, Twentieth Annual Report, Part IV, page 230.

Daily gage height, in feet, of Mississippi River at St. Paul, Minnesota, for 1899.[1]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	Frozen.	Frozen.	Frozen.	Frozen.	6.4	5.7	8.	4.0	7.5	4.4	7.2	4.7
2	do	do	do	do	6.6	6.6	8.7	3.8	7.2	4.3	7.1	4.7
3	do	do	do	do	6.8	7.7	8.5	3.7	6.9	4.2	7.0	4.6
4	do	do	do	do	7.0	8.2	8.3	3.7	6.7	4.2	6.8	4.5
5	do	do	do	do	7.1	8.5	8.0	3.6	6.4	4.2	6.7	4.2
6	do	do	do	do	7.2	8.7	7.8	3.5	6.2	4.1	6.6	3.2
7	do	do	do	do	7.5	9.2	7.5	3.5	6.2	4.1	6.5	2.5
8	do	do	do	5.0	7.6	9.6	7.3	3.5	6.1	4.1	6.4	2.5
9	do	do	do	6.9	7.5	9.7	7.0	3.5	5.9	4.0	6.2	3.2
10	do	do	do	7.4	7.2	9.8	6.8	3.	5.8	4.0	6.1	4.2
11	do	do	do	7.5	6.9	9.9	6.5	3.9	5.7	4.0	6.0	4.6
12	do	do	do	8.1	6.7	9.7	6.2	4.0	5.7	4.1	6.0	4.4
13	do	do	do	9.8	6.5	9.9	6.0	4.1	5.7	4.1	5.9	Frozen.
14	do	do	do	10.5	6.2	10.0	5.9	3.8	5.6	4.3	5.8	Do.
15	do	do	do	10.3	6.1	10.3	5.9	3.8	5.6	4.4	5.7	Do.
16	do	do	do	10.4	6.0	10.5	6.0	3.8	5.6	4.6	5.6	Do.
17	do	do	do	10.4	6.1	10.6	5.7	4.0	5.5	5.3	5.5	Do.
18	do	do	do	10.4	6.1	10.8	5.4	4.0	5.3	5.8	5.4	Do.
19	do	do	do	10.1	6.0	10.9	5.2	4.0	5.2	6.7	5.4	Do.
20	do	do	do	9.5	5.9	10.9	5.	4.3	5.1	7.5	5.3	Do.
21	do	do	do	8.8	5.9	10.9	5.0	4.6	5.0	8.0	5.2	*a* 4.8
22	do	do	do	8.0	5.9	11.0	5.0	5.8	5.0	8.4	5.1	*a* 4.8
23	do	do	do	7.4	5.9	11.0	5.0	6.6	5.0	8.7	5.0	*a* 4.8
24	do	do	do	7.0	5.8	10.9	4.8	8.0	5.0	8.8	5.0	*a* 4.8
25	do	do	do	6.7	5.8	10.7	4.7	8.7	4.9	8.7	5.0	*a* 4.8
26	do	do	do	6.5	5.8	10.3	4.6	8.8	4.9	8.6	5.0	*a* 4.8
27	do	do	do	6.3	5.7	9.9	4.5	8.7	4.8	8.2	4.9	*a* 4.8
28	do	do	do	6.1	5.8	9.5	4.3	8.5	4.8	8.0	4.9	*a* 4.8
29	do	.....	do	6.1	5.8	9.2	4.2	8.3	4.7	7.8	4.8	*a* 4.6
30	do	.....	do	6.2	5.7	8.8	4.1	8.0	4.5	7.6	4.8	*a* 4.6
31	do	.....	do	.....	5.7	.....	4.0	7.7	.....	7.4	.....	*a* 4.6

a Estimated.

WEST GALLATIN RIVER AT SALESVILLE, MONTANA.

This stream has its source in the northwestern corner of Yellowstone National Park and flows in a northerly direction, joining Madison and Gallatin rivers near Threeforks to form the Missouri River. The upper 75 miles of its course is in a canyon the scenery of which rivals many of the noted canyons of Yellowstone National Park. Surveys for a road up this canyon have been made in order to reach the road system that the Government has built in the park, but the plans have not yet been carried out. About 10 miles above Salesville, Montana, the river leaves its canyon and enters the Gallatin Valley, which has an extent, in round numbers, of 1,200 square miles. This area has been noted for a number of years for its fertility; immense crops of hay and cereals are yearly matured here. The land is irrigated from canals taken from the Gallatin River and a number of tributaries, including Middle Creek, Bozeman Creek, and East Gallatin River. On certain bench lands against the sides of the surrounding mountains dry farming is practiced, or, in other words, crops are raised without irrigation. Two gaging stations are maintained on this river, one near Salesville and the other at Logan, near its mouth. The Salesville station, which has been maintained for a number of years, is located at the highway bridge crossing the stream about 5 miles south of Salesville. Kleinschmidt ditch, having a capacity of 75 second-feet but carrying of late years not over 40 second-feet, diverts water from the river above the station. A gage rod was erected in 1895 and

[1] Records kept by United States Weather Bureau.

spiked to a tree; in 1896 a wire gage was placed on the bridge, and the two gages made to read the same. The bench mark is the head of the southwest bolt in the rim of the southeast cylindrical pier, and its elevation is 13.70 feet above gage datum. The observer is Ira T. Williams, of Salesville, Montana. The results of discharge measurements are shown as follows: 1896, Eighteenth Annual Report, Part IV, page 126; 1897, Nineteenth Annual Report, Part IV, page 276; 1898, Twentieth Annual Report, Part IV, page 241. The following measurements were made under the supervision of Samuel Fortier during 1899:

March 21, gage height, 2.90 feet; discharge, 474 second-feet.
April 6, gage height, 2.80 feet; discharge, 766 second-feet.
April 13, gage height, 3.25 feet; discharge, 719 second-feet.
May 1, gage height, 3.40 feet; discharge, 830 second-feet.
May 9, gage height, 4.00 feet; discharge, 1,056 second-feet.
June 10, gage height, 5.35 feet; discharge, 2,607 second-feet.
August 30, gage height, 3.88 feet; discharge, 711 second-feet.

Daily gage height, in feet, of West Gallatin River at Salesville, Montana, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.10	2.70	.....	.....	3.30	4.70	7.30	4.60	3.80	3.50	.....	.....
2	3.10	.....	.....	2.80	3.20	5.10	7.30	4.50	3.80	3.50	.....	.....
3	3.10	.....	.....	2.80	3.10	5.50	7.30	4.50	3.80	3.50	.....	3.10
4	3.10	.....	.....	2.80	3.20	6.10	7.30	4.50	3.70	3.50	.....	.....
5	3.10	3.10	2.90	2.80	3.30	5.65	7.20	4.50	3.70	3.50	3.50	.....
6	3.10	.....	.....	2.80	3.40	5.00	7.20	4.40	3.70	3.50	.....	.....
7	3.10	.....	.....	2.90	3.50	5.00	7.10	4.40	3.70	3.50	.....	.....
8	3.10	.....	2.90	3.20	3.70	4.95	7.05	4.35	3.70	3.50	.....	.....
9	3.10	.....	.....	3.30	3.90	5.05	7.00	4.30	3.70	3.50	.....	.....
10	3.10	.....	.....	3.30	3.90	4.30	6.95	4.30	3.70	3.50	.....	3.10
11	.....	.....	.....	3.30	4.00	5.70	6.85	4.20	3.60	3.50	.....	.....
12	.....	3.10	2.90	3.30	4.10	6.05	6.75	4.20	3.60	3.50	3.50	.....
13	.....	.....	.....	3.20	4.00	6.15	6.45	4.20	3.60	3.50	.....	.....
14	.....	.....	.....	3.10	3.90	6.50	6.25	4.10	3.60	3.50	.....	.....
15	3.04	.....	.....	3.10	3.90	6.95	5.95	4.10	3.60	3.50	.....	.....
16	.....	.....	.....	3.20	3.90	7.05	5.75	4.10	3.60	3.50	.....	.....
17	.....	.....	2.90	3.10	3.85	7.25	5.55	4.10	3.60	3.50	.....	3.40
18	.....	.....	.....	3.00	3.80	7.60	5.40	4.10	3.60	3.50	.....	.....
19	3.00	3.00	2.90	3.00	3.80	8.10	5.30	4.10	3.60	3.50	3.50	.....
20	.....	.....	.....	3.00	3.80	8.55	5.30	4.10	3.60	3.50	.....	.....
21	.....	.....	.....	3.10	3.90	8.10	5.30	4.00	3.60	3.50	.....	.....
22	.....	.....	.....	3.20	4.15	7.35	5.20	3.90	3.60	3.50	.....	.....
23	.....	.....	.....	3.30	4.30	6.70	5.10	3.90	3.60	3.50	.....	.....
24	.....	.....	2.90	3.30	4.50	6.90	5.00	3.90	3.60	3.50	.....	3.30
25	2.90	.....	.....	3.30	4.55	7.00	5.00	3.90	3.60	3.50	.....	.....
26	.....	2.90	.....	3.40	4.65	7.10	4.90	3.90	3.50	3.50	3.50	.....
27	.....	.....	.....	3.50	4.55	7.20	4.85	3.90	3.50	3.50	.....	.....
28	.....	.....	.....	3.50	4.50	7.20	4.80	3.90	3.50	3.50	.....	.....
29	2.80	.....	.....	3.30	4.60	7.20	4.70	3.80	3.50	.....	.....	.....
30	.....	.....	.....	3.30	4.65	7.30	4.70	3.80	3.50	.....	.....	.....
31	.....	.....	2.80	3.30	4.70	.....	4.60	3.80	.....	.....	.....	.....

MIDDLE CREEK NEAR BOZEMAN, MONTANA.

This creek, a tributary of East Gallatin River, has its source on the northern slope of the Gallatin Range. Although it drains a small area, it is an important stream, on account of its water supply, which is used for irrigation purposes in the vicinity of Bozeman. The gage station is located 9 miles south of Bozeman and one-eighth of a mile above the old sawmill dam in the creek canyon. Discharge measurements are made from a wire cable placed across the stream in [illegible]. The gage is about 200 feet below the cable, and consists of a

zontal frame supporting a wire gage. Bench mark No. 1 consists of a spike driven horizontally into a stump 5 feet high about 80 feet east of the gage rod. The middle of this spike is at an elevation of 7.03 feet above gage datum. Bench mark No. 2 consists of an 8-inch bridge spike driven horizontally into a charred stump about 25 feet northeast of the gage, with an elevation of 3.58 feet. Bench mark No. 3 consists of a large rock 93 feet east of the gage, marked "B. M." in black paint, and is 4.84 feet above gage datum. Results of discharge measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 128; 1898, Twentieth Annual Report, Part IV, page 243. The following measurements were made under the direction of Samuel Fortier during 1899:

Measurements of Middle Creek near Bozeman, Montana.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
Mar. 14	0.05	78	June 28	1.20	426
Apr. 4	.05	86	July 7	.98	440
Apr. 12	.05	79	July 18	.80	384
May 7	.10	92	July 26	.60	246
June 16	.90	351	Aug. 26	.15	77

Daily gage height, in feet, of Middle Creek at Bozeman, Montana, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1						0.70	1.30	0.40	0.10	0.00
2						1.20	1.10	.40	.10	.05
3	—0.25					1.10	1.00	.40	.13	.00
4						1.70	.95	.40	.10	.00
5						1.00	1.00	.40	.10	.00
6		—0.15				.80	1.00	.35	.10	.00
7			—0.05		0.20	.70	.95	.40	.10	.00
8					.20	.60	1.10	.35	.10	.08
9			— .10		.28	.70	1.00	.35	.10	.00
10					.40	.85	1.20	.30	.08	.00
11					.50	1.10	1.00	.30	.08	.00
12					.43	1.20	.95	.30	.05	.00
13	.00				.35	.90	.90	.30	.05	.00
14			— .08		.30	.80	.85	.25	.05	.00
15			— .08		.20	.80	.80	.20	.05	.00
16					.23	1.10	.80	.20		.00
17	— .10				.30	1.50	.80	.20	.04	.00
18					.28	1.60	.80	.20	.04	.00
19					.30	1.60	.95	.20	.03	.00
20					.28	1.70	.85	.20	.01	.00
21					.25	1.60	.75	.15	.01	.00
22					.23	1.40	.60	.15	.01	.00
23		— .05	— .05		.30	1.60	.55	.15	.01	.00
24	— .10				.68	1.00	.50	.15	.00	.00
25					.70	1.35	.65	.15	.00	.00
26					.65	1.35	.60	.15	.00	.00
27					.60	1.35	.60	.10	.00	.00
28		— .75	— .08		.70	1.15	.50	.10	.00	.00
29					.70	1.50	.50	.10	.00	.00
30	— .10		— .05		.50	1.30	.45	.10	.00	.00
31					.70		.40	.10		.00

GALLATIN RIVER AT LOGAN, MONTANA.

The main Gallatin River is formed by the junction of the East and West Gallatin rivers 5 miles above Logan. The wire gage is located on the east span of the railroad bridge. Bench mark No. 1 is the top

of the northeast corner of the iron plate at foot of diagonal end member of truss east end upper side, and is 13.70 feet above datum. Bench mark No. 2 consists of the head of a bridge spike driven vertically into the top of a pile stump, to which the lower end of the old incline gage is fastened; it is 0.162 foot above gage datum. Discharge measurements are made from the cable across the river 300 feet above the railroad bridge, and show the amount of water available after the diversion as above. The section is a good one, the channel being straight for some distance above and below the gaging cable. The results of measurements are published as follows: 1896, Eighteenth Annual Report, Part IV, page 129; 1897, Nineteenth Annual Report, Part IV, page 278; 1898, Twentieth Annual Report, Part IV, page 240. The following measurements were made under the direction of Samuel Fortier during 1899:

March 18, gage height, 1.00 foot; discharge, 580 second-feet.
April 9, gage height, 1.90 feet; discharge, 1,120 second-feet.
April 24, gage height, 1.60 feet; discharge, 1,089 second-feet.
May 22, gage height, 2.20 feet; discharge, 1,786 second-feet.
July 14, gage height, 3.00 feet; discharge, 1,079 second-feet.
July 30, gage height, 1.90 feet; discharge, 760 second-feet.

Daily gage height, in feet, of Gallatin River at Logan, Montana, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.00	1.50	3.05	5.00	1.90	1.50	1.30	1.50	.....
2	.....	1.00	1.50	3.10	5.00	1.80	1.50	1.30	1.50	.....
3	.....	1.00	1.50	3.35	4.45	1.80	1.40	1.30	1.50	.....
4	.....	1.15	1.50	4.10	4.30	1.80	1.40	1.30	1.50	.....
5	.....	1.05	1.50	4.05	4.05	1.80	1.40	1.30	.....	.....
6	1.00	1.40	1.55	3.80	3.90	1.80	1.40	1.30	.....	1.50
7	1.20	1.80	1.60	3.45	3.75	1.80	1.40	1.30	.....	.....
8	1.35	1.95	1.65	3.25	3.55	1.80	1.40	1.30	1.50	.....
9	1.45	2.65	1.85	3.10	3.50	1.80	1.40	1.30	.....	.....
10	1.25	3.25	2.20	3.35	3.50	1.90	1.40	1.30	.....	.....
11	1.10	2.85	2.35	3.65	3.50	1.90	1.40	1.30	.....	.....
12	1.00	3.10	2.45	4.25	3.30	1.90	1.40	1.30	.....	.....
13	1.00	2.70	2.60	4.35	3.05	1.90	1.40	1.30	.....	1.60
14	1.00	2.40	2.75	4.05	3.00	1.90	1.40	1.30	.....	.....
15	1.00	1.85	2.80	3.80	2.90	1.90	1.40	1.30	1.50	.....
16	1.00	2.15	2.75	4.00	2.80	1.80	1.40	1.30	.....	.....
17	1.00	2.00	2.80	4.35	2.70	1.80	1.40	1.30	.....	.....
18	1.00	1.90	2.55	5.25	2.60	1.70	1.40	1.30	.....	.....
19	1.00	1.80	2.00	5.65	2.60	1.70	1.40	1.30	.....	.....
20	1.00	1.80	1.90	5.90	2.45	1.70	1.40	1.30	.....	1.60
21	1.10	1.50	1.90	6.25	2.40	1.70	1.40	1.30	.....	.....
22	1.10	1.75	2.05	5.60	2.40	1.70	1.40	1.30	1.50	.....
23	1.10	1.70	2.15	4.90	2.35	1.65	1.30	1.50	.....	.....
24	1.20	1.60	2.45	4.75	2.25	1.60	1.30	1.70	.....	.....
25	1.50	1.60	2.75	4.85	2.10	1.60	1.30	1.65	.....	.....
26	1.35	1.60	2.90	5.20	2.00	1.60	1.30	1.60	.....	.....
27	1.30	1.60	2.90	5.20	1.90	1.60	1.30	1.50	.....	.....
28	1.10	1.60	2.90	5.00	1.90	1.60	1.30	1.50	.....	.....
29	1.00	1.60	2.90	5.10	1.90	1.55	1.30	1.50	1.60	(a)
30	1.00	1.60	3.00	5.05	1.90	1.50	1.30	1.50	.....	.....
31	1.00	.....	3.05	.....	1.90	1.50	.....	1.50	.....	.....

January 1 to March 6 river frozen; no readings. *a* Frozen.

A measurement of Bridger Creek, a tributary of East Gallatin River, was made August 3 at the highway bridge at the fish hatchery in the canyon, and showed a discharge of 25 second-feet.

O

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891–93, Part II, Papers of an economic character, 1893; octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894; octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Bighorn Range and Bighorn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar years 1893 and 1894, by F. H. Newell, 1895; octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography, 1896; octavo, 864 pp.

Contains papers on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett; and "Preliminary report on the artesian areas of a portion of the Dakotas," by N. H. Darton.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 330 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 356 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896–97, Part IV, Hydrography, 1897; octavo, 756 pp.

Contains a "Report of progress of stream measurements for the year 1896," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "New developments in well boring and irrigation in South Dakota," by N. H. Darton; and "Reservoirs for irrigation," by J. D. Schuyler.

1899.

Nineteenth Annual Report of the United States Geological Survey, 1897–98, Part IV, Hydrography, 1899; octavo, 814 pp.

Contains a "Report of progress of stream measurements for the calendar year 1897," by F. H. Newell and others; "The rock waters of Ohio," by Edward Orton; and "Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian," by N. H. Darton.

1900.

Twentieth Annual Report of the United States Geological Survey, 1898–99, Part IV, Hydrography, 1900; octavo, 600 pp.

Contains a "Report of progress of stream measurements for the calendar year 1898," by F. H. Newell, and "Hydrography of Nicaragua," by A. P. Davis.

WATER-SUPPLY AND IRRIGATION PAPERS, 1896–1899.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost, as noted above. Postage stamps, checks, and drafts can not be accepted. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Correspondence relating to the publications of the Survey should be addressed to The Director, United States Geological Survey, Washington, D. C.

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phoenix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897.
7. Seepage waters of northern Utah, by Samuel Fortier, 1897.
8. Windmills for irrigation, by E. C. Murphy, 1897.
9. Irrigation near Greeley, Colorado, by David Boyd, 1897.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker, 1898.
11. River heights for 1896, by Arthur P. Davis, 1897.
12. Underground waters of southeastern Nebraska, by N. H. Darton, 1898.
13. Irrigation systems in Texas, by W. F. Hutson, 1898.
14. New tests of pumps and water lifts used in irrigation, by O. P. Hood, 1898.
15. Operations at river stations, 1897, Part I, 1898.
16. Operations at river stations, 1897, Part II, 1898.
17. Irrigation near Bakersfield, California, by C. E. Grunsky, 1898.
18. Irrigation near Fresno, California, by C. E. Grunsky, 1898.
19. Irrigation near Merced, California, by C. E. Grunsky, 1899.
20. Experiments with windmills, by Thomas O. Perry, 1899.
21. Wells of northern Indiana, by Frank Leverett, 1899.
22. Sewage irrigation, Part II, by George W. Rafter, 1899.
23. Water-right problems of Bighorn Mountains, by Elwood Mead, 1899.
24. Water resources of the State of New York, Part I, by George W. Rafter, 1899.
25. Water resources of the State of New York, Part II, by George W. Rafter, 1899.
26. Wells of southern Indiana (continuation of No. 21), by Frank Leverett, 1899.
27. Operations at river stations, 1898, Part I, 1899.
28. Operations at river stations, 1898, Part II, 1899.
29. Wells and windmills in Nebraska, by Erwin Hinckley Barbour, 1899.
30. Water resources of the Lower Peninsula of Michigan, by Alfred C. Lane, 1899.
31. Lower Michigan mineral waters, by Alfred C. Lane, 1899.
32. Water resources of Puerto Rico, by H. M. Wilson, 1900.
33. Storage of water on Gila River, Arizona, by J. B. Lippincott, 1900.
34. Geology and water resources of southeastern S. Dak., by J. E. Todd, 1900.
35. Operations at river stations, 1899, Part I, 1900.
36. Operations at river stations, 1899, Part II, 1900.
37. Operations at river stations, 1899, Part III, 1900.
38. Operations at river stations, 1899, Part IV, 1900.

In addition to the above, there are, in various stages of preparation, other pap relating to the measurement of streams, the storage of water, the amount availa from underground sources, the efficiency of windmills, the cost of pumping, other details relating to the methods of utilizing the water resources of the co try. Provision has been made for printing these by the following clause in sundry civil act making appropriations for the year 1896–97:

Provided, That hereafter the reports of the Geological Survey in relation to gaging of streams and to the methods of utilizing the water resources may printed in octavo form, not to exceed 100 pages in length and 5,000 copies in nu ber; 1,000 copies of which shall be for the official use of the Geological Surv 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered the House of Representatives, for distribution. (Approved, June 11, 1896; Stat vol. 29, p. 453.)

The maximum number of copies available for the use of the Geological Sur is 1,000. This quantity falls far short of the demand, so that it is impossible supply all requests. Attempts are made to send these pamphlets to persons w have rendered assistance in their preparation through replies to schedules or w have furnished data. Requests made for a certain paper and stating a reason asking for it are granted whenever practicable, but it is impossible to comply w *general* demands, such as to have all of the series sent indiscriminately.

Application for these papers should be made either to members of Congress o

THE DIRECTOR, UNITED STATES GEOLOGICAL SURVEY, WASHINGTON, D.

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 37

OPERATIONS AT RIVER STATIONS, 1899.—PART III

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

IRRIGATION REPORTS.

The following list contains the titles and brief descriptions of the principal reports relating to water supply and irrigation prepared by the United States Geological Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 123 pp.

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo, 395 pp.

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889-90. Contains a description of the hydrography of the arid region and of the engineering operations carried on by the Irrigation Survey during 1890; also the statement of the Director of the Survey to the House Committee on Irrigation, and other papers, including a bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891; octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890-91. Contains "Report upon the location and survey of reservoir sites during the fiscal year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; "Irrigation in India," by Herbert M. Wilson. Illustrated by 98 plates and 190 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell; quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 83, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No. 178, Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 23, September 9, 1892; quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a résumé of the water supply and a description of irrigation by artesian wells. Illustrated by colored maps, showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-92, Part III, Irrigation, 1893; octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American irrigation engineering" and "Engineering results of the Irrigation Survey," by Herbert M. Wilson; "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnaissance in central Washington, by Israel Cook Russell, 1893; octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical conditions and local peculiarities in each county

Fourteenth Annual Report of the United States Geological Survey, 1892-93, in two parts: Part II, Accompanying papers, 1894; octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W J McGee; "Natural mineral waters of the United States," by A. C. Peale; "Results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 37

WASHINGTON
GOVERNMENT PRINTING OFFICE
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J. C. Branner

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

'ERATIONS AT RIVER STATIONS, 1899

A REPORT OF THE

DIVISION OF HYDROGRAPHY

OF THE

UNITED STATES GEOLOGICAL SURVEY

PART III

WASHINGTON
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OPERATIONS AT RIVER STATIONS, 1899.

PART III.

MEASUREMENTS AT RIVER STATIONS.[1]

MADISON RIVER AT REDBLUFF, MONTANA.

This river has its source in the central portion of the Yellowstone National Park, and flows in a general northerly direction, joining the Jefferson and Gallatin rivers near Threeforks to form the Missouri River. Some distance beyond the western boundary of the park an opening of considerable extent occurs, known as the Upper Madison Valley. Below Meadow Creek the bluffs close in again, and the river is in canyon to below the mouth of Cherry Creek. Beyond this it gradually opens into the lower valley. The country about the head waters of the stream is too high for profitable farming, except for summer stock ranging. Less water can be used for irrigation from this stream than from the other two tributaries of the Missouri, but the fall is admirably adapted for power purposes, and a number of surveys have been made in this connection. The gage rod, which was established May 2, 1897, is located at the ranch of the observer, Mrs. S. A. Black, 3 miles below the Redbluff iron county bridge over the Madison and about 1½ miles below the mouth of Cherry Creek. Discharge measurements are made at the highway bridge above. Cherry Creek enters between the bridge and the gage rod, and it is necessary to measure its discharge whenever a measurement of the main river is made. On June 3 its discharge was 366 second-feet, and on June 29 its discharge was 186 second-feet. Results of measurements are published as follows: 1897, Nineteenth Annual Report, Part IV, page 280; 1898, Twentieth Annual Report, Part IV, page 236. The following discharge measurements, not including Cherry Creek, were made in 1899 under the direction of Samuel Fortier:

June 3, gage height, 2.50 feet; discharge, 4,784 second-feet.
June 30, gage height, 3.30 feet; discharge, 7,616 second-feet.

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[1] Continued from Water-Supply and Irrigation Paper No. 36.

Daily gage height, in feet, of Madison River at Redbluff, Montana, for 1896.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.65	2.60	3.65	1.70	1.40	1.30	.....	.....
2	.....	1.65	2.60	3.40	1.70	1.40	1.30	.....	.....
3	.....	1.65	2.70	3.30	1.70	1.40	1.30	1.30	.....
4	.....	1.65	2.70	3.20	1.65	1.40	1.30	.....	.....
5	.....	1.65	2.80	3.10	1.60	1.40	1.30	.....	.....
6	.....	1.65	2.70	2.90	1.70	1.40	1.30	.....	.....
7	.....	1.65	2.80	2.85	1.80	1.40	1.30	.....	(a)
8	.....	1.70	2.80	2.80	1.80	1.40	1.30	.....	.....
9	.....	1.75	2.90	2.75	1.85	1.40	1.30	.....	.....
10	.....	1.75	3.00	2.70	1.80	1.40	1.30	.....	.....
11	.....	1.80	3.10	2.60	1.75	1.40	1.30	.....	.....
12	.....	1.80	3.25	2.55	1.70	1.40	1.30	.....	.....
13	.....	1.85	3.40	2.45	1.70	1.40	1.30	.....	.....
14	.....	1.10	3.50	2.30	1.70	1.40	1.30	.....	.....
15	.....	1.10	3.70	2.30	1.70	1.40	1.30	.....	(a)
16	1.60	1.95	3.90	2.10	1.60	1.40	1.30	1.30	.....
17	1.60	1.90	3.80	2.00	1.60	1.40	1.30	.....	.....
18	1.60	1.10	3.70	1.90	1.55	1.40	1.30	.....	.....
19	1.55	1.10	3.70	1.90	1.50	1.40	1.30	.....	.....
20	1.55	1.10	3.70	1.90	1.40	1.40	1.30	.....	.....
21	1.60	1.10	3.60	1.95	1.40	1.40	1.30	.....	.....
22	1.65	1.10	3.60	2.00	1.40	1.40	1.30	.....	.....
23	1.60	1.10	3.60	2.00	1.40	1.40	1.30	1.30	.....
24	1.60	1.10	3.65	1.90	1.40	1.40	1.30	.....	.....
25	1.60	1.55	3.60	1.80	1.40	1.40	1.30	.....	.....
26	1.55	2.10	3.60	1.80	1.40	1.40	1.30	.....	.....
27	1.65	2.30	3.60	1.65	1.40	1.40	1.30	.....	.....
28	1.65	2.50	3.60	1.60	1.40	1.40	1.30	.....	(a)
29	1.65	2.50	3.65	1.60	1.40	1.40	1.30	.....	.....
30	1.65	2.50	3.70	1.70	1.40	1.40	1.30	(a)	.....
31	.....	2.60	.....	1.70	1.40	.....	1.30	.....	.....

January 1 to April 15, river frozen; no readings. a Ice.

JEFFERSON RIVER AT SAPPINGTON, MONTANA.

This river is formed by the union of Bighole and Beaverdam rivers near Twin Bridges, Montana. The former stream has its source in the highest parts of the Rocky Mountains, which form the Continental Divide and the State boundary line between Montana and Idaho. The head-water tributary of Beaverdam River is Redrock Creek, rising in in the southwestern part of the State, about 20 miles west of the boundary line of Yellowstone National Park. Jefferson River is one of the main streams that unite at Threeforks to form the Missouri River. This latter name should apply to the Jefferson and its tributary, Redrock Creek, as this is the longest of the three head-water streams of the Missouri. Irrigation is practiced to a limited extent in the upper reaches of the Jefferson, mainly for forage plants. From Twin Bridges downstream to the mouth of the North and South Boulder creeks is an extent of tillable land, which, however, has been little utilized up to the present time. The river is in canyon from Boulder Creek to about Willow Creek, whence the gorge gradually widens out into the Gallatin Valley. The station on this river is located at Sappington, 7 miles above Willow Creek, and was established by Arthur P. Davis November 13, 1894. The wire gage is fastened to the guard rail on the upper side of the Northern Pacific Railway bridge, 1 mile north of the railroad station. Bench mark No. 1 consists of a 6-inch wire nail driven horizontally in the east side of the blocking which forms the south abutment of the railroad bridge and is 6.90 feet above gage

datum. Bench mark No. 2 is a 6-inch wire nail in a telegraph pole, about 30 feet south and east of the south abutment of the bridge, and is at an elevation of 7 feet on the gage. Bench mark No. 3 is the head of the northwest bolt fastening the switch standard to the cross-tie, 30 feet east of the bridge. Its elevation is 15.67 feet. On November 3, 1897, the rod was lowered eight-tenths of a foot, the subsequent readings being adjusted to the new datum. Discharge measurements are made from a cable and car erected a short distance above the bridge. Results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 134; 1897, Nineteenth Annual Report, Part IV, page 281; 1898, Twentieth Annual Report, Part IV, page 238. The following measurements were made during 1899 by Samuel Fortier:

April 10, gage height, 2.70 feet; discharge, 2,891 second-feet.
April 24, gage height, 2.80 feet; discharge, 2,595 second-feet.
May 21, gage height, 4.50 feet; discharge, 6,505 second-feet.
July 13, gage height, 5.40 feet; discharge, 4,847 second-feet.
July 29, gage height, 3.10 feet; discharge, 2,909 second-feet.

Daily gage height, in feet, of Jefferson River at Sappington, Montana, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.70	3.00	5.80	7.60	3.10	2.30	2.10	2.90	2.60
2	.....	2.70	3.00	5.80	7.55	3.00	2.30	2.10	2.80	2.60
3	.....	2.70	2.90	6.15	7.35	3.00	2.30	2.10	2.80	2.60
4	.....	2.70	2.85	7.00	7.20	2.90	2.30	2.10	2.80	2.60
5	.....	2.70	2.80	7.30	6.90	2.90	2.30	2.10	2.80	2.60
6	.....	2.70	3.05	7.40	6.70	2.90	2.30	2.10	2.80	2.60
7	.....	2.70	3.20	7.00	6.50	2.90	2.30	2.10	2.80	2.60
8	.....	2.70	3.60	6.50	6.10	2.80	2.30	2.10	2.80	2.60
9	.....	2.70	4.10	6.20	5.85	2.80	2.30	2.10	2.80	2.60
10	.....	2.70	4.55	5.95	5.65	2.80	2.30	2.10	2.80	2.60
11	.....	2.70	4.95	6.10	5.60	2.90	2.30	2.20	2.80	2.80
12	.....	2.70	5.15	6.65	5.50	3.00	2.30	2.30	2.80	2.80
13	.....	2.70	5.35	7.40	5.40	3.00	2.30	2.30	2.80	3.00
14	.....	2.70	5.25	7.80	5.40	2.95	2.30	2.40	2.80	3.00
15	.....	2.70	4.95	8.00	5.25	2.90	2.30	2.40	2.80	.....
16	.....	2.70	4.60	7.70	5.20	2.80	2.30	2.50	2.80	.....
17	.....	2.70	4.25	7.30	4.85	2.80	2.30	2.50	2.80	.....
18	.....	3.00	4.40	7.40	4.75	2.70	2.30	2.60	2.80	.....
19	.....	2.90	4.50	7.85	4.60	2.60	2.30	2.70	2.80	.....
20	.....	2.85	4.60	8.50	4.45	2.60	2.30	2.70	2.80	.....
21	.....	2.70	4.45	9.00	4.35	2.60	2.30	2.80	2.70	.....
22	.....	2.70	4.40	9.60	4.25	2.60	2.30	2.90	2.70	.....
23	.....	2.70	4.40	9.65	4.05	2.60	2.30	2.90	2.60	.....
24	.....	2.70	4.50	9.10	3.85	2.80	2.30	2.90	2.60	.....
25	.....	2.70	4.65	8.30	3.65	2.80	2.30	2.90	2.60	.....
26	.....	2.80	5.35	8.00	3.45	2.80	2.20	2.90	2.60	.....
27	.....	3.00	5.65	8.00	3.25	2.70	2.20	2.90	2.60	.....
28	.....	3.15	5.90	7.80	3.10	2.70	2.20	2.90	2.60	.....
29	2.70	3.20	5.90	7.60	3.10	2.50	2.10	2.90	2.60	.....
30	2.70	3.10	5.80	7.70	3.10	2.50	2.10	2.90	2.60	.....
31	2.70	.....	5.80	.....	3.10	2.40	.....	2.90	.....	.....

January 1 to March 28, river frozen; no readings.
December 15 to 31, river frozen; no readings.

MISSOURI RIVER AT TOWNSEND, MONTANA.

This river is formed by the junction of the Jefferson, Madison, and Gallatin rivers at Threeforks, Montana. Observations of gage heights are maintained at Townsend by the Missouri River Commission, and although the section is not an ideal one, it still seems desirable to make occasional discharge measurements as the station is easily accessible and daily gage observations are taken at no expense to this Survey. The gage is located at the wagon bridge about a mile north of the railroad station. The heights given are the means of two daily readings expressed in feet above the St. Louis directrix, which is 412.73 feet above mean gulf level. In the following table, furnished by Charles Keller, first lieutenant, Corps of Engineers, United States Army, the figures 3,300 have been omitted, and it is therefore necessary to add this amount to obtain the elevation of the water surface above the St. Louis datum. Results of measurements are found as follows: 1896, Eighteenth Annual Report, Part IV, page 124; 1897, Nineteenth Annual Report, Part IV, page 283; 1898, Twentieth Annual Report, Part IV, page 244. The following discharge measurements were made during 1899 under the direction of Samuel Fortier:

May 30, gage height, 92.00; discharge, 13,021 second-feet.
June 15, gage height, 93.80 feet; discharge, 29,832 second-feet.
July 21, gage height, 90.90 feet; discharge, 8,842 second-feet.

Daily gage height, in feet, of Missouri River at Townsend, Montana, for 1899.

Day.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	90.10	91.90	94.10	89.90	89.15	88.90	89.30	89.30
2	.....	89.90	92.20	94.05	89.90	89.10	88.90	89.30	89.30
3	.....	89.80	92.40	93.95	89.85	89.10	89.00	89.30	89.30
4	88.40	89.80	92.85	93.60	89.80	89.10	89.00	89.30	89.10
5	88.50	89.80	93.35	93.35	89.70	89.10	89.05	89.35	89.00
6	88.80	89.80	93.50	93.05	89.70	89.10	89.00	89.35	89.05
7	89.30	89.90	93.30	92.80	89.70	89.05	89.00	89.35	89.10
8	89.80	90.30	93.10	92.60	89.75	89.00	89.00	89.35	89.10
9	89.90	90.60	92.60	92.55	89.80	89.00	89.00	89.35	89.10
10	90.20	91.05	92.30	92.45	89.95	89.00	89.10	89.35	89.10
11	90.40	91.25	92.45	92.35	89.95	89.00	89.10	89.35	*a* 89.10
12	90.55	91.55	92.80	92.25	89.90	89.00	89.15	89.40	89.10
13	90.85	91.70	93.40	92.05	89.85	89.00	89.20	89.40	89.10
14	90.45	91.60	93.70	92.00	89.80	89.05	89.20	89.40	89.10
15	90.00	91.60	93.75	91.80	89.70	89.10	89.20	89.40	89.10
16	90.00	91.50	93.75	91.65	89.65	89.15	89.20	89.40	*a* 89.10
17	90.05	91.35	93.60	91.50	89.55	89.10	89.20	89.45	89.10
18	89.95	91.25	93.70	91.20	89.50	89.10	89.20	89.45	89.10
19	89.90	91.15	94.10	91.05	89.50	89.10	89.30	89.45	89.15
20	89.75	91.10	94.60	90.95	89.50	89.10	89.40	89.45	89.20
21	89.70	91.10	95.20	90.90	89.45	89.00	89.45	89.40	89.25
22	89.90	91.05	95.35	90.85	89.50	89.00	89.50	89.30	89.20
23	90.00	91.00	95.65	90.70	89.50	89.00	89.55	89.25	89.20
24	89.95	91.00	95.75	90.60	89.50	89.05	89.60	89.20	89.30
25	89.95	91.05	95.25	90.40	89.45	89.00	89.65	89.20	89.40
26	90.15	91.40	94.55	90.30	89.40	89.00	89.50	89.20	89.50
27	90.40	91.60	94.40	90.10	89.40	89.00	89.50	89.15	89.55
28	90.20	92.05	94.45	90.05	89.30	88.95	89.50	89.20	89.65
29	90.10	92.00	94.20	90.00	89.20	88.90	89.40	89.20	*b* 91.70
30	90.10	92.00	94.20	90.00	89.20	88.90	89.40	89.25	90.90
31	.....	91.95	.....	89.95	89.20	.....	89.40	.....	90.90

a Ice readings, December 11 to 16. *b* Ice gorged December 29.

MILK RIVER AT HAVRE, MONTANA.

er rises on the eastern slope of the Rocky Mountains in the orthern part of Montana. The head-water tributaries have northeasterly direction, crossing the international boundary British territory, in which there is a large area drained. reenters the United States farther eastward and flows in a outherly direction to Havre. Its course is thence easterly oins the Missouri River near Glasgow, Montana, at the ern corner of Fort Peck Indian Reservation. The valley er is fertile and well adapted for raising the hardier grains. ent in this direction has been somewhat slow until within the ears. The area drained by Milk River is to a large extent airie lands, excellent for grazing purposes and covered with owth of grass. The discharge measurements show the f water available for the canals, a number of which have een taken from the river below Havre, as described in the 1 Annual Report, Part IV, page 286. The present station at Havre, Montana, and was established by Cyrus C. Babb, 898. The gage rod is an especial form described in Water-aper No. 27, page 68. Measurements of discharge are 1 a car and cable of 200-foot span swung across the river a ance above the gage. The river is subject to violent floods uration, and the bed of the river being composed of gravels s liable to change after each freshet. Results of measure-1898 are shown in the Eighteenth Annual Report, Part IV,

The following discharge measurements were made by g in 1899:

Measurements of Milk River at Havre, Montana.

ate.	Gage height.	Dis-charge.	Date.	Gage height.	Dis-charge.
899.	*Feet.*	*Sec.-ft.*	1899.	*Feet.*	*Sec.-ft.*
.....	3.20	1,410	July 31	1.00	228
.....	2.20	807	Aug. 3	1.10	252
.....	1.90	732	Aug. 5	1.40	379
.....	2.60	1,087	Aug. 11	.80	182
.....	2.50	911	Aug. 16	.50	111
.....	3.50	1,657	Aug. 19	.40	105
.....	3.40	1,653	Aug. 25	.60	137
.....	2.90	1,126	Aug. 28	.80	158
.....	2.80	1,210	Sept. 2	.60	137
.....	2.30	661	Sept. 7	.30	99
.....	2.00	586	Sept. 12	.20	88
.....	1.90	588	Sept. 15	.30	96
.....	1.40	353	Sept. 21	1.50	360
.....	1.20	298	Sept. 25	1.90	221
.....	1.25	314	Sept. 30	1.50	122
.....	.80	181	Oct. 16	1.40	109
.....	.60	150	Oct. 24	1.70	146
.....	.70	170	Nov. 6	2.40	308

Day.	Jan.	Feb.	Apr.	May.	Sept.	Oct.	Nov.	Dec.
1				2.00	0.60	1.40	1.30	
2	1.40			1.90	.60	1.30	1.30	
3				1.90	.50	1.40	1.30	(a)
4		1.80		1.90	.50	1.30	1.30	
5				1.90	.40	1.30	2.40	
6				2.60	.40	1.20	2.40	
7	1.40			2.60	.30	1.10		
8				2.60	.40	1.30		
9	1.40			2.50	.40	1.30		
10				2.50	.30	1.30		(a)
11				2.50	.30	1.20		
12				2.50	.20	1.00	2.20	
13				2.55	.20			
14	1.40			2.60	.20			
15				2.60	.30	1.30		
16			4.60	2.60	.20	1.30		
17			4.30	2.60	.40	1.20		(a)
18			3.90	2.70	1.50	1.10		
19		1.90	3.40	2.70	1.60	1.10	1.10	
20		2.50	3.20	2.70	1.10	1.10		
21	1.80		3.20	2.70	1.90	1.00		
22			3.05	2.95	2.00	1.20		
23			2.80	3.30	2.00	1.10		
24	1.80		2.55	3.20	1.90	1.10		(a)
25			2.50	3.20	1.80	1.00		
26			2.50	2.70	1.70	1.30		
27			2.40	2.80	1.60	1.30	1.90	
28	1.80		2.35		1.40	1.40		
29			2.20		1.50	1.40		
30			2.00		1.60	1.40		
31						1.30		

a Frozen.

YELLOWSTONE RIVER AT LIVINGSTON, MONTANA.

This river has its source in Yellowstone Lake, in the National Park, and flows in a northerly direction into Montana. Its course is thence easterly to its junction with the Missouri River, near the North Dakota line. Owing to the fact of the numerous springs of the park which contribute to its flow, and also to the fact that the lake acts as a regulator, the discharge when it crosses the Montana line is large for a river of this section of the country. Yellowstone Valley is the largest body of irrigable land in Montana, having a length of about 500 miles. At the present time it is principally utilized as a range for a vast number of cattle and sheep. With its comparatively low altitude of 2,500 feet, the section is well adapted for the future development of irrigation. The gaging station established May 2, 1897, is located at the highway bridge over the Yellowstone River, 5 miles south of Livingston, at the mouth of the canyon. A wire gage is in use. A new bench mark was established in 1899, as follows: The top of the end plate of bridge at upper side of east end, at an elevation of 14.20 feet above zero of gage. The slope of the water surface at gaging station was found to be 0.146 feet in 200 feet on August 29, 1899. The observer is Thomas S. Carter, who lives at the end of the bridge. The results of measurements may be found as follows: 1897, Nineteenth Annual Report, Part IV, page 289; 1898, Twentieth

Annual Report, Part IV, page 248. The following measurements of discharge were made under the direction of Samuel Fortier in 1899:

March 10, gage height, 1.00 foot; discharge, 1,702 second-feet.
March 24, gage height, 1.10 feet; discharge, 1,801 second-feet.
April 5, gage height, 1.10 feet; discharge, 1,868 second-feet.
April 14, gage height, 1.40 feet; discharge, 2,629 second-feet.
May 28, gage height, 3.70 feet; discharge, 6,964 second-feet.
June 21, gage height, 8.00 feet; discharge, 22,053 second-feet.
July 20, gage height, 5.30 feet; discharge, 7,283 second-feet.
August 29, gage height, 1.86 feet; discharge, 5,337 second-feet.

Daily gage height, in feet, of Yellowstone River at Livingston, Montana, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	0.85	0.90	1.60	4.20	7.88	4.10	1.70	0.55	.....	.....
2	.....	.....	.85	.95	1.53	4.35	7.58	4.00	1.70	.50	0.05	.....
3	.....	(a)	.85	.95	1.43	5.03	7.30	3.90	1.70	.45	.....	—0.30
4	.....	.....	.90	1.00	1.40	5.40	7.15	3.80	1.68	.43	.05	.....
5	0.60	.....	.90	1.10	1.40	5.35	7.08	3.70	1.60	.40	.....	.....
6	.....	.....	.90	1.10	1.48	4.85	7.00	3.70	1.48	.40	.....	.....
7	.....	.....	.90	1.10	1.60	4.48	6.93	3.60	1.40	.40	.....	.....
8	.....	.....	.95	1.10	1.80	4.38	6.95	3.50	1.33	.38	.....	.....
9	.....	.....	1.00	1.13	2.25	4.35	6.95	3.50	1.30	.35	.....	— .80
10	.....	.....	1.00	1.30	2.73	5.00	6.75	3.63	1.28	.35	.....	.....
11	.....	.....	.80	1.30	3.00	5.50	6.65	3.35	1.20	.35	.00	.....
12	.70	.....	.85	1.30	3.30	6.20	6.55	3.25	1.15	.35	.....	.....
13	.....	.70	.90	1.50	3.40	5.60	6.20	3.10	1.15	.35	.....	.....
14	.....	.....	.85	1.43	3.10	5.28	5.93	3.03	1.15	.35	.....	.....
15	.....	.....	.80	1.25	2.90	5.20	5.75	2.98	1.15	.35	.....	.....
16	.....	.....	.85	1.38	2.75	5.63	5.65	2.83	1.10	.30	.....	(a)
17	.....	.85	.95	1.40	2.58	6.68	5.55	2.73	1.03	.30	.....	.....
18	.....	.....	.95	1.35	2.53	7.60	5.38	2.70	1.00	.30	— .10	.....
19	.....	.....	.93	1.28	2.70	8.05	5.30	2.65	.93	.30	.....	.....
20	.....	.....	.90	1.23	2.90	8.55	5.28	2.53	.90	.40	.....	.....
21	.90	.....	(a)	1.20	2.90	8.30	5.28	2.43	.85	.35	.....	.....
22	.....	.....	.88	1.35	2.80	7.15	5.13	2.40	.83	.43	.....	.....
23	.....	.....	.93	1.50	2.75	6.73	4.85	2.35	.75	.43	.....	— .50
24	.....	.80	1.05	1.55	3.13	6.95	4.68	2.28	.73	.40	.....	.....
25	.....	.....	1.15	1.80	4.03	7.25	4.60	2.18	.70	.35	— .35	.....
26	.90	.....	1.05	2.00	4.35	7.60	4.50	2.10	.70	.23	.....	.....
27	.....	.....	.78	1.95	3.95	7.60	4.48	1.98	.70	.20	.....	.....
28	.....	.....	.90	1.78	3.85	7.60	4.30	1.90	.65	.18	.....	.....
29	.....	.....	1.00	1.63	4.00	7.78	4.30	1.83	.60	.15	.....	.....
30	.....	.....	1.00	1.60	4.25	8.05	4.30	1.80	.58	.15	.....	— .80
31	.....	.....	.90	.....	4.20	.....	4.15	1.75	.....	.10	.....	.....

a Frozen.

BIGHORN RIVER AT THERMOPOLIS, WYOMING.

A number of discharge measurements were made on this river at Thermopolis, Wyoming, by A. J. Parshall, during the progress of a survey in that vicinity, which he had undertaken for the State. A bench mark was established on the pile near the ferry, and the gage heights noted are the distance of water surface below this bench mark; they are, therefore, in reverse order to the usual records of water heights. Four measurements were made during 1899, as follows:

July 28, gage height, 8 feet below bench mark; discharge, 4,867 second-feet.
August 7, gage height, 8.38 feet below bench mark; discharge, 4,204 second-feet.
August 16, gage height, 8.98 feet below bench mark; discharge, 2,673 second-feet.
September 14, gage height, 9.74 feet below bench mark; discharge, 1,162 second-feet.

SHOSHONE RIVER AT LOVELL, WYOMING.

The source of this river is in the high mountain peaks along the eastern border of the Yellowstone National Park. It has a general northeasterly course and enters Bighorn River about 12 miles above the Montana State line. Irrigation is practiced to a limited extent in the upper headwaters, but principally from the small tributaries, as Trout, Rattlesnake, and Cottonwood creeks. Below the junction of the North and South forks a number of large irrigation enterprises have recently been undertaken. A gaging station was established May 23, 1897, at Lovell, Wyoming. The rod is fastened to the landing pier of the ferry on the south side of the river. The channel is straight for some distance above and below the rod, and the cross section at the gaging point has a uniform depth. The bed of the river is stable. The results of measurements are shown as follows: 1897, Nineteenth Annual Report, Part IV, page 292; 1898, Twentieth Annual Report, Part IV, page 249. No discharge measurements were made at this station during 1899.

Daily gage height, in feet, of Shoshone River at Lovell, Wyoming, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	−.80	0.60	3.80	+0.20	−1.10	17	−.90	−.40	3.00	2.60	−.50	−1.50
2	.....	−.80	.60	3.60	+.00	−1.10	18	−.80	−.40	3.90	2.60	−.50	−1.50
3	.....	−.70	3.00	3.40	−.10	−1.20	19	−.70	−.40	4.30	2.70	−.60	−1.50
4	.....	−.70	.60	3.20	−.30	−1.20	20	−.60	+.10	4.20	2.60	−.60	−1.50
5	.....	−.70	.30	3.20	−.20	−1.20	21	−.40	.30	4.00	2.50	−.70	−1.50
6	.....	−.50	.90	3.10	−.30	−1.20	22	−.20	.20	2.70	2.50	−.80	−1.50
7	.....	−.50	.70	3.10	−.20	−1.20	23	.00	.10	2.50	2.50	−.90	−1.50
8	.....	−.40	.50	3.00	−.30	−1.30	24	+.70	.50	2.50	1.40	−.90	−1.50
9	.....	−.20	.90	3.20	−.30	−1.30	25	+.60	.90	2.90	1.40	−.90	−1.50
10	.....	+.20	1.30	2.90	−.30	−1.30	26	−.60	.70	3.50	1.00	−1.00	−1.50
11	.....	.30	2.00	2.80	−.30	−1.40	27	−.70	.70	3.30	1.00	−1.00	−1.50
12	−0.80	.30	2.80	2.70	−.30	−1.40	28	−.70	.80	3.40	1.40	−1.00	−1.50
13	−.90	.20	2.00	2.80	−.30	−1.40	29	−.70	.70	3.70	1.30	−1.00	−1.50
14	−.90	−.10	1.50	2.90	−.30	−1.40	30	−.70	.80	4.00	1.70	−1.00	−1.50
15	−.80	−.40	1.40	2.70	−.40	−1.40	31	.....	.70	.....	1.10	−1.00	.....
16	−.80	−.20	2.20	2.60	−.40	−1.40							

CLEAR CREEK AT BUFFALO, WYOMING.

This creek is one of the most important tributaries of Powder River, having its source in the summit of the Bighorn Mountains. The irrigating system diverting water from this stream has been described in detail in earlier reports. The point of measurement is about 4 miles west of Buffalo, Wyoming, at which point is a flume erected in 1889. Of late years this station is not considered as important as formerly, on account of the diversions of water which have taken place within its basin. The earlier discharge measurements established a rating for the measuring flume, and it has not been necessary to make any since. The results of measurements are shown as follows: 1896, Eighteenth Annual Report, Part IV, page 140; 1897, Nineteenth Annual Report, Part IV, page 298; 1898, Twentieth Annual Report,

Part IV, page 250. No measurements of discharge were made at this point during 1899.

Daily gage height, in feet, of Clear Creek at Buffalo, Wyoming, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.30				0.60	1.13	1.80	1.35	0.50	0.48	0.50	
2					.50	1.18	1.53	1.27	.49	.50	.45	
3					.50	1.63	1.47	1.18	.47	.49	.43	0.45
4				0.30	.50	1.37	1.46	1.15	.57	.50	.42	
5		0.25	0.25		.45	1.34	1.46	1.12	.57	.49	.42	
6					.52	1.24	1.45	1.03	.58	.49	.48	
7					.73	1.20	1.40	.94	.57	.50	.47	
8	.33				.52	1.15	1.43	.81	.57	.50	.48	
9					.54	1.14	1.41	.70	.56	.57	.49	
10					.67	1.11	1.42	.73	.56	.56	.47	.40
11					.58	1.26	1.39	.69	.50	.56	.48	
12			.30	.40	.64	1.34	1.33	.64	.50	.57	.47	
13					.70	1.39	1.39	.60	.50	.59	.49	
14					.60	1.26	1.37	.59	.50	.58	.50	
15	.30				.69	1.23	1.39	.59	.60	.59	.47	
16					.70	1.23	1.35	.58	.50	.60	.48	
17					.69	1.40	1.20	.56	.48	.60	.48	.40
18					.70	2.15	1.20	.57	.62	.60	.49	
19		.25		.60	.77	2.43	1.25	.53	.61	.59	.49	
20					1.17	2.42	1.21	.54	.61	.58		
21					1.20	2.45	1.23	.58	.60	.56		
22					.90	1.75	1.23	.57	.58	.53		
23					.90	1.45	1.44	.55	.52	.57		
24					1.10	1.46	1.75	.53	.54	.55		.40
25					1.24	1.89	1.73	.52	.51	.44		
26		.25			1.20	2.07	1.73	.50	.50	.42	.45	
27					1.13	1.73	1.70	.50	.51	.49		
28					1.12	1.64	1.70	.49	.50	.48		
29					1.12	1.72	1.58	.48	.49	.47		.40
30				.63	1.21	1.87	1.42	.49	.49	.39		
31					1.14		1.42	.49		.48		

MINNECHADUSA RIVER AT VALENTINE, NEBRASKA.

This stream rises in South Dakota, flows into Nebraska, and empties into Niobrara River near Valentine. Measurements have been made at the times when the regular river station on Niobrara River at Fort Niobrara has been visited. The results are of value as showing the flow available for milling purposes, there being little, if any, opportunity for irrigation. Measurements were made by Glenn E. Smith at a point 1 mile above the town. The channel at this point is straight, and the water moves with moderate velocity. The banks are high and the bed sandy. Most of the measurements were made by wading. Results for 1899 are as follows:

January 27, 26.2 second-feet; February 21, 45.0 second-feet; March 5, 25.7 second-feet; April 26, 32.6 second-feet; May 11, 35.6 second-feet; June 23, 23.0 second-feet; August 12, 19.0 second-feet; September 13, 23.5 second-feet; September 26, 26.5 second-feet; October 20, 20.0 second-feet.

NIOBRARA RIVER AT FORT NIOBRARA, NEBRASKA.

This river rises in eastern Wyoming and flows across the State line into Nebraska, continuing along the northern side of that State near the boundary of South Dakota until it enters the Missouri River at the northeastern corner of Nebraska. A gaging station was estab-

lished by O. V. P. Stout on July 22, 1897, three-fourths of a mile southwesterly from Fort Niobrara and above the mouth of Minnechadusa River. It was afterwards discontinued, but was resumed on April 26, 1899, when a rod was located 195 feet downstream from the wagon bridge near Fort Niobrara. The rod is solidly bedded on cross-ties and well fastened with bridge spikes. It is a new 3 by 4 inch oak rod 10 feet long, and is placed on the left bank of the stream. Bench mark No. 1 is the top of a large spike driven in the top of a 2 by 4 inch timber which is set 4 feet in the ground and 12 feet west of the rod, and is 5.63 feet above gage datum. Bench mark No. 2 is the top of the short cap at shoe of truss at west end of the bridge, downstream side, and is 9.98 feet above the zero of the gage. Bench mark No. 3 is the top of the plate of the center pier of the bridge, downstream side, and is 10.03 feet above gage datum. Thomas Dillon, mail carrier between Valentine and Fort Niobrara, is the observer. The results of measurement are shown as follows: 1897, Nineteenth Annual Report, Part IV, page 300; 1898, Twentieth Annual Report, Part IV, page 255. The following discharge measurements were made by Glenn E. Smith during 1899:

Measurements of Niobrara River at Fort Niobrara, Nebraska.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Second-ft.*	1899.	*Feet.*	*Second-ft.*
Jan. 27	Frozen.	623	July 16	1.52	788
Mar. 15	Frozen.	726	Aug. 13	1.30	718
Mar. 15	Frozen.	*a* 650	Aug. 30	1.35	700
Apr. 25	1.15	952	Sept. 13	1.15	695
May 11	1.18	867	Sept. 26	1.05	732
May 26	1.44	1,031	Oct. 7	1.15	776
June 23	1.24	733	Oct. 20	0.80	849

a Measurement made at point 5 miles south of Valentine.

Daily gage height, in feet, of Niobrara River at Fort Niobrara, Nebraska, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	1.13	1.31	1.21	1.31	1.24	17	.....	1.12	1.41	1.51	1.41	1.24
2	.....	1.11	1.31	1.41	1.34	1.24	18	.....	1.14	1.41	1.44	1.44	1.21
3	.....	1.12	1.34	1.34	1.51	1.31	19	.....	1.21	1.34	1.41	1.41	1.14
4	.....	1.12	1.31	1.23	1.41	1.31	20	.....	1.22	1.24	1.41	1.34	1.14
5	.....	1.14	1.31	1.24	1.34	1.24	21	.....	1.23	1.23	1.41	1.32	1.24
6	.....	1.21	1.21	1.34	1.34	1.21	22	.....	1.24	1.23	1.31	1.34	1.21
7	.....	1.13	1.14	1.41	1.31	1.21	23	.....	1.34	1.22	1.31	1.34	1.11
8	.....	1.24	1.12	1.41	1.31	1.21	24	.....	1.44	1.22	1.31	1.34	1.11
9	.....	1.31	1.12	1.41	1.41	1.24	25	.....	1.34	1.51	1.24	1.24	1.14
10	.....	1.14	1.12	1.42	1.34	1.21	26	1.14	1.44	1.21	1.21	1.24	1.12
11	.....	1.14	1.24	1.44	1.31	1.21	27	1.14	1.41	1.31	1.24	1.24	1.14
12	.....	1.14	1.44	1.44	1.34	1.14	28	1.21	1.42	1.34	1.24	1.24	1.11
13	.....	1.14	1.34	1.51	1.41	1.14	29	1.21	1.41	1.34	1.31	1.31	1.11
14	.....	1.14	1.21	1.42	1.21	1.14	30	1.13	1.42	1.41	1.31	1.31	1.11
15	.....	1.14	1.21	1.51	1.31	1.24	31	.....	1.31	.....	1.31	1.21	.....
16	.....	1.11	1.24	1.54	1.41	1.21							

LARAMIE RIVER AT WOODS LANDING, WYOMING.

This river, a tributary of the North Platte River, entering it at Fort Laramie, Wyoming, has its source in the mountains of northern Colorado, adjoining the head waters of the Cache la Poudre on the west.

Irrigation is practiced on a small scale in Colorado, but principally for hay ranches, as the elevation is too great for diversified farming. One important diversion—that of the Sky-line canal—takes water from the Laramie, carrying it across the divide and into Cache la Poudre drainage. This diversion is working a hardship to the Wyoming appropriators below, as many in this State have prior rights to Sky-line canal, but owing to the present water laws the Wyoming rancher has no redress through the courts. Laramie River, on crossing the Wyoming line, soon leaves its canyon and enters the Laramie Plains, which are extensively irrigated from the main stream and from the various tributaries, notably from Little Laramie River, whose low-water flow is now entirely used. Lower down on its course the river passes through another canyon, to enter finally the plain of the Lower Laramie, which extends from the eastern edge of the Laramie Hills to the mouth of the river. A notable diversion in this section of the country is that of the Wyoming Development Company, taking water from Laramie River about 27 miles southwest of Wheatland. This canal system is more fully described in the Nineteenth Annual Report, Part IV, page 303. Two gaging stations are maintained on the river, one at Woods Landing, a short distance after the river appears in Wyoming, and the other at Uva, near its mouth. The former station is 26 miles from Laramie, Wyoming, and is reached by stage. Measurements of discharge are made from the wagon bridge which spans the river at this point.

The gage rod is fastened to a perpendicular post set firmly in the bed of the stream and braced at the top to adjacent trees, and is about 400 feet above the bridge. The bench mark is a nail in a notch on a cottonwood tree 1 foot in diameter, 6 feet from the rod, and is on a level with the 7-foot mark on the rod. The measurements here show the amount of water available for the use of the irrigators below. The bottom of the stream is composed of large granite bowlders, which renders the shape and slope of the channel practically unchangeable, but adds an element of uncertainty to the gaging results, owing to the difficulty of determining the correct cross section. Results of measurements are published as follows: 1896, Eighteenth Annual Report, Part IV, page 147; 1897, Nineteenth Annual Report, Part IV, page 302; 1898, Twentieth Annual Report, Part IV, page 274. The following measurements of discharge were made by A. J. Parshall in 1899:

May 26, gage height, 3.30 feet; discharge, 2,598 second-feet.
June 8, gage height, 3.10 feet; discharge, 2,319 second-feet.
June 21, gage height, 4.40 feet; discharge, 4,145 second-feet.
July 6, gage height, 2.80 feet; discharge, 2,194 second-feet.

Daily gage height, in feet, of Laramie River at Woods Landing, Wyoming, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1			2.00	2.00	1.20	3.15	3.75	1.40	0.80	0.40		
2				2.00	1.10	3.25	3.65	1.40	0.75	0.40		
3	2.00	2.00		2.00	1.00	3.25	3.50	1.55	0.75	0.40		
4				2.00	1.00	3.15	3.50	1.70	0.70	0.40		
5				2.00	1.00	2.95	3.10	1.75	0.60	0.50		
6				2.00	1.20	3.05	2.80	1.70	0.60	0.50		
7				2.00	1.30	3.00	2.70	1.60	0.60	0.65	0.60	0.90
8			2.00	2.00	1.40	3.00	2.60	1.50	0.50	0.75		
9				2.00	1.50	3.00	2.45	1.40	0.50	0.80		
10	2.10	2.00		2.00	1.60	3.05	2.35	1.35	0.50	0.85		
11				2.00	1.75	3.45	2.50	1.20	0.55	0.80		
12				2.00	1.95	3.80	2.65	1.10	0.50	0.80		
13				2.00	2.30	4.30	2.65	1.10	0.50	0.70		
14				2.00	2.55	4.35	2.55	1.03	0.50	0.70	0.70	1.10
15			2.00	2.00	2.60	3.75	2.45	1.00	0.60	0.70		
16				2.00	2.65	3.50	2.30	1.00	0.65	0.70		
17	2.00	2.00		1.90	2.55	3.75	2.20	0.90	0.60	0.70		
18				1.90	2.45	3.85	2.05	0.90	0.60	0.70		
19				1.80	2.60	3.95	2.00	0.90	0.60	0.60		
20				1.80	2.65	4.15	1.85	0.90	0.60	0.70		
21				1.70	2.75	4.25	1.80	0.85	0.50	0.75	0.70	1.00
22			2.00	1.70	2.85	4.45	1.85	0.80	0.50	0.70		
23				1.60	2.95	4.50	1.80	0.80	0.50	0.70		
24	2.00			1.50	3.10	4.40	1.80	0.80	0.50	0.60		
25		2.00		1.50	3.20	4.65	1.75	0.78	0.50	0.60		
26				1.40	3.20	4.55	1.75	0.75	0.40	0.60		
27				1.40	3.10	4.40	1.75	0.70	0.40	0.60		
28				1.30	3.25	4.15	1.90	0.60	0.40	0.60	0.80	1.20
29				1.20	3.35	4.05	1.75	0.60	0.40	8.60		
30				1.15	3.30	3.90	1.60	0.75	0.50	0.60		
31					3.05		1.45	0.90		0.60		

LARAMIE RIVER AT UVA, WYOMING.

This station is located 18 miles, by wagon road, from the mouth of the river at Fort Laramie, and the results obtained show practically the amount of water passing out of the State from this drainage area. The rod is fastened to the railroad bridge of the Cheyenne Northern Railway, a half mile from the town of Uva, while discharge measurements are made from the wagon bridge 1,000 feet below. The bench mark is a spike head on the south side of a pile on the east end of railroad bridge, and is 11.95 feet above zero of gage. The bed of the river is sandy and liable to change during high water. The results of measurements are shown as follows: 1896, Eighteenth Annual Report, Part IV, page 149; 1897, Nineteenth Annual Report, Part IV, page 302; 1898, Twentieth Annual Report, Part IV, page 176. The following measurements of discharge were made by A. J. Parshall in 1899:

April 25, gage height, 3 feet; discharge, 863 second-feet.
May 6, gage height, 2.80 feet; discharge, 530 second-feet.
May 30, gage height, 4.40 feet; discharge, 2,022 second-feet.
June 13, gage height, 4.50 feet; discharge, 2,144 second-feet.
June 26, gage height, 5.80 feet; discharge, 3,472 second-feet.
July 13, gage height, 3.95 feet; discharge, 1,607 second-feet.

Daily gage height, in feet, of Laramie River at Uva, Wyoming, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.80	1.40	1.50	1.50	3.00	4.60	5.30	2.20	1.20	0.90	.....	.....
2	.....	.....	.....	1.50	2.90	4.70	5.30	2.20	1.20	0.90	.....	1.50
3	.....	.....	.....	1.40	2.90	4.80	5.00	2.20	1.20	0.90	.....	.....
4	.....	.....	.....	1.40	2.80	4.80	4.90	2.10	1.20	0.90	1.60	.....
5	.....	.....	.....	1.50	2.80	4.80	5.00	2.10	1.20	0.90	.....	.....
6	.....	.....	.....	1.60	2.80	4.80	5.10	2.10	1.20	0.90	.....	.....
7	.....	.....	1.50	1.80	2.80	4.70	4.90	2.00	1.20	0.90	.....	.....
8	1.00	1.40	.....	1.80	2.60	4.60	4.70	2.00	1.20	0.90	.....	.....
9	.....	.....	.....	2.00	2.40	4.20	4.70	2.00	1.60	1.00	.....	1.40
10	.....	.....	.....	3.00	2.20	4.10	4.60	2.00	1.50	1.10	.....	.....
11	.....	.....	.....	3.40	2.00	4.10	4.40	2.00	1.40	1.20	1.40	.....
12	.....	.....	.....	5.60	1.90	4.20	4.20	1.90	1.30	1.20	.....	.....
13	.....	.....	.....	5.10	1.90	4.30	4.20	1.90	1.10	1.20	.....	.....
14	.....	.....	1.60	5.40	1.80	4.30	4.10	1.90	1.10	1.30	.....	.....
15	1.00	1.50	.....	4.80	1.80	4.80	4.00	1.90	1.10	1.30	.....	.....
16	.....	.....	.....	4.40	2.55	5.00	4.00	2.00	1.10	1.30	.....	2.00
17	.....	.....	.....	4.30	3.40	5.50	4.00	2.00	1.00	1.30	.....	.....
18	.....	.....	.....	4.20	3.40	5.50	3.80	2.00	1.00	1.30	1.50	.....
19	.....	.....	.....	3.20	3.30	5.60	3.60	2.00	1.00	1.30	.....	.....
20	.....	.....	.....	3.60	4.80	5.60	3.50	1.90	1.00	1.40	.....	.....
21	.....	.....	1.60	3.00	4.80	5.60	3.30	1.90	1.00	1.40	.....	.....
22	1.40	1.50	.....	3.00	4.50	5.50	3.10	1.80	1.00	1.40	.....	.....
23	.....	.....	.....	3.30	4.40	5.50	3.00	1.70	1.00	1.40	.....	1.60
24	.....	.....	.....	3.20	4.60	5.60	2.90	1.60	1.00	1.40	.....	.....
25	.....	.....	.....	3.00	4.80	5.60	2.80	1.50	1.00	1.50	1.50	.....
26	.....	.....	.....	3.00	4.90	5.80	2.60	1.40	1.00	1.50	.....	.....
27	.....	.....	.....	3.10	4.80	6.00	2.60	1.40	0.90	1.60	.....	.....
28	.....	1.50	1.50	3.00	4.60	5.90	2.50	1.40	0.90	1.60	.....	.....
29	1.80	.....	.....	3.00	4.50	5.80	2.40	1.40	0.90	.....	.....	.....
30	.....	.....	.....	3.00	4.40	5.70	2.40	1.30	0.90	.....	.....	1.90
31	.....	.....	.....	.....	4.40	.....	2.30	1.30	.....	.....	.....	.....

NORTH PLATTE RIVER AT ORIN JUNCTION, WYOMING.

This river has its source in the mountains of North Park in northern Colorado. The general elevation of the park is 8,000 feet, and it is surrounded by mountains which attain an elevation of 12,000 feet. Irrigation is practiced to a considerable extent from small ditches, which are used almost entirely, however, in flooding native grass lands for forage purposes. The river passes through a short, narrow canyon on entering Wyoming, and thence flows northerly through the upper Platte Valley, which extends from the State line down to Fort Steel. The river thence continues northerly, receiving a number of important tributaries, notably Sweetwater River, in the basin of which considerable irrigation is practiced. The only station maintained in this State on this stream at present is at Orin Junction, at the bridge of the Cheyenne Northern Railway. The rod is attached to the mid-channel pier of the railroad bridge, and is connected with the following bench marks: The spike on top of the cap on the set of piles nearest the water at the east end of the bridge is 11.52 feet above gage datum. The bed of the stream is composed of heavy gravel and sand, the cross section being quite uniform. Measurements at this point are not altogether satisfactory, on account of the occurrence of bridge piers, which interfere with the uniform flow to a considerable extent. Results of measurements are found as follows: 1896, Eighteenth Annual Report, Part IV, page 153; 1897, Nineteenth Annual Report, Part IV, page 307; 1898, Twentieth Annual Report, Part IV,

page 266. The following discharge measurements were made during 1899 by A. J. Parshall:

April 24, gage height, 4.26 feet; discharge, 5,239 second-feet.
May 5, gage height, 3.70 feet; discharge, 4,115 second-feet.
May 19, gage height, 5.70 feet; discharge 13,422 second-feet.
June 12, gage height, 5.85 feet; discharge, 14,746 second-feet.
June 26, gage height, 6.85 feet; discharge, 20,855 second-feet.
July 12, gage height, 5.67 feet; discharge, 10,784 second-feet.
September 2, gage height, 1 foot; discharge, 239 second-feet.

Daily gage height, in feet, of North Platte River at Orin Junction, Wyoming, for 1899.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	Ice.	.....	4.45	6.10	6.40	3.00	1.00	.....	1.60	.....
2	.....	.....	.....	4.25	5.95	.....	2.93	.98	1.00	.....	.....
3	.....	.....	.....	4.00	5.75	6.40	2.83	.....	1.00	.....	.....
4	4.55	3.00	.....	3.85	.....	6.30	2.73	.95	1.00	.....	.....
5	.....	.....	.....	3.70	6.15	6.20	2.55	.95	1.00	.....	.....
6	.....	.....	.....	3.65	6.20	6.15	.....	.95	.98	.....	.....
7	.....	.....	.....	.....	6.20	5.95	2.58	.95	.93	.....	.....
8	.....	.....	.....	3.35	6.15	5.75	2.75	.95	.....	1.40	Ice.
9	.....	.....	.....	3.45	5.95	.....	2.73	.95	1.00	.....	.....
10	.....	.....	2.65	3.85	5.75	5.35	2.70	.....	1.08	.....	.....
11	4.45	Ice.	2.85	4.15	.....	5.15	2.63	.90	1.25	.....	.....
12	.....	.....	3.95	4.30	5.95	4.98	2.45	.90	1.18	.....	.....
13	.....	.....	5.05	4.50	6.10	4.88	.....	.90	1.05	.....	.....
14	.....	.....	5.45	.....	6.50	4.83	2.08	.90	1.05	.....	.....
15	.....	.....	5.30	5.45	6.75	4.95	2.03	.95	.....	1.30	Ice.
16	.....	.....	.....	5.75	6.80	.....	1.93	1.60	1.20	.....	.....
17	.....	.....	5.05	5.85	6.80	4.75	1.83	.....	1.35	.....	.....
18	5.10	Ice.	4.80	5.95	.....	4.68	1.73	1.40	1.63	.....	.....
19	.....	.....	4.70	6.05	6.35	4.45	1.60	1.30	1.70	.....	.....
20	.....	.....	4.45	6.20	6.30	4.20	.....	1.65	1.70	.....	.....
21	.....	.....	4.10	.....	6.55	4.08	1.60	1.58	1.63	.....	.....
22	.....	.....	3.85	6.30	6.85	3.85	1.60	1.48	.....	1.30	Ice.
23	.....	.....	.....	6.20	6.95	.....	1.53	1.38	1.50	.....	.....
24	.....	.....	4.05	6.00	7.15	3.73	1.43	.....	1.50	.....	.....
25	.....	4.00	4.30	5.75	.....	3.63	1.33	1.23	1.58	.....	.....
26	.....	.....	4.90	5.55	6.85	3.60	1.23	1.20	1.73	.....	.....
27	.....	.....	5.70	5.35	6.65	3.45	.....	1.00	1.75	.....	.....
28	5.15	.....	5.70	.....	6.45	3.28	1.03	1.00	1.83	.....	.....
29	.....	.....	5.65	5.75	6.40	3.05	1.00	1.00	.....	1.25	Ice.
30	.....	.....	.....	6.05	6.40	.....	1.00	1.00	1.73	.....	Ice.
31	.....	.....	.....	6.10	.....	3.00	1.00	.....	1.60	.....	.....

NORTH PLATTE RIVER AT GERING, NEBRASKA.

This river does not receive any tributaries of importance after passing into Nebraska. A number of canals divert water between the State line and North Platte, at the junction of the North and South Platte rivers, and because of the nonincrease of the flow from important tributaries the water is constantly being reduced. A gaging station was established at Gering, Nebraska, May 29, 1897, and is located at the highway bridge at this point. The rod is fastened to one of the bridge piles. The bench mark is the head of a nail on top of the west end of the first cap at the south end of the bridge, and is 6.61 feet above gage datum. The results of discharge measurements are shown as follows: 1897, Nineteenth Annual Report, Part IV, page 308; 1898, Twentieth Annual Report, Part IV, page 267. The following discharge measurements were made by R. H. Willis *during 1899:*

Measurements of North Platte River at Gering, Nebraska.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
.....	1.48	3,464	July 6	3.09	15,996
.....	2.10	9,776	July 11	2.75	12,808
.....	2.35	11,096	July 18	2.38	11,232
.....	2.10	8,575	July 26	1.90	6,198
.....	2.90	12,942	Aug. 10	1.48	3,677
.....	2.70	13,799	Aug. 18	1.40	2,658
.....	2.90	14,176	Aug. 24	1.18	2,150
.....	3.00	18,227	Sept. 21	1.05	860
.....	3.55	23,473	Sept. 30	.95	957

age height, in feet, of North Platte River at Gering, Nebraska, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
.....	.....	2.35	2.70	3.20	1.65	1.05	0.93
.....	.....	2.37	2.71	3.15	1.70	1.02	.95
.....	.....	2.35	2.66	3.10	1.75	1.00	.95
.....	.....	2.10	2.61	3.07	1.70	1.02	.96
.....	.....	2.00	2.60	3.10	1.58	1.04	.95
.....	.....	1.95	2.72	3.05	1.55	1.01	.95
.....	.....	1.80	3.10	3.00	1.51	1.01	.96
.....	.....	1.75	3.00	2.95	1.47	1.00	.96
.....	.....	1.73	2.83	2.87	1.48	1.00	.96
.....	1.48	1.70	2.73	2.70	1.53	1.00	.97
.....	1.41	1.68	2.69	2.75	1.47	1.00	1.06
.....	1.53	1.64	2.68	2.68	1.50	1.00	1.07
.....	1.85	1.82	2.80	2.55	1.48	1.00	1.07
.....	2.22	1.93	2.90	2.46	1.37	.95	1.06
.....	2.42	2.00	3.00	2.45	1.35	.95	1.07
.....	2.51	2.25	3.20	2.44	1.43	1.00	1.04
.....	2.58	2.40	3.25	2.42	1.40	.98	1.10
.....	2.38	2.60	3.15	2.37	1.37	1.00	1.02
.....	2.43	2.76	3.00	2.30	1.36	1.00	1.16
.....	2.20	2.80	2.95	2.25	1.32	1.06	1.20
.....	2.21	2.85	3.00	2.13	1.26	1.06	1.23
.....	2.08	2.87	3.05	2.05	1.23	.98	1.25
.....	1.92	2.87	3.20	2.00	1.23	1.03	1.27
.....	1.90	3.10	3.27	2.00	1.20	1.03	1.23
.....	1.88	2.85	3.50	1.95	1.20	.98	1.23
.....	1.93	2.65	3.55	1.90	1.10	.98	1.23
.....	2.12	2.43	3.50	1.85	1.10	1.00	1.27
.....	2.40	2.41	3.20	1.81	1.10	.98	1.30
.....	2.39	2.43	3.27	1.77	1.13	.91	1.30
.....	2.37	2.52	3.25	1.67	1.10	.90	1.30
.....	.....	2.70	.....	1.67	1.07	.....	1.30

Closed for winter October 31.

NORTH PLATTE RIVER AT CAMP CLARKE, NEBRASKA.

d gaging station on this river is located at the bridge at Camp Nebraska, and was established on June 27, 1896. The rod of an oak timber 2 by 4 inches, 10 feet long, fastened to cross-ch are bedded in the bank of the river. Bench mark No. 1 of a spike driven horizontally in the northeast side of the eam pile of the bent at the north end of the first truss span, outh end of the bridge, and is 7.55 feet above gage datum. nark No. 2 is a point on the southeast corner of the window he front of the store, and is 9.74 feet above the zero of the The results of measurements may be found as follows: 1896, nth Annual Report, Part IV, page 154; 1897, Nineteenth

Annual Report, Part IV, page 308; 1898, Twentieth Annual Report, Part IV, page 268. The following discharge measurements were made by R. H. Willis in 1899:

Measurements of North Platte River at Camp Clarke, Nebraska.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
Apr. 11	2.57	2,823	July 20	3.97	9,855
Apr. 22	3.45	8,625	July 29	3.09	4,747
May 3	3.41	7,982	Aug. 5	2.90	4,187
May 17	3.52	9,646	Aug. 12	2.92	3,272
May 27	3.90	13,492	Aug. 19	2.67	2,359
June 8	4.42	15,607	Aug. 29	2.46	1,492
June 17	4.45	18,237	Sept. 5	2.13	965
June 24	5.05	18,330	Sept. 14	2.05	758
June 28	5.00	22,903	Sept. 23	2.03	794
July 8	4.76	18,705	Sept. 29	2.10	863
July 13	4.25	12,268	Oct. 19	2.15	1,110

Daily gage height, in feet, of North Platte River at Camp Clarke, Nebraska, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1		3.68	4.12	4.81	2.88	2.28	2.28
2		3.73	4.18	4.83	2.98	2.22	2.27
3		3.30	4.12	4.85	3.10	2.06	2.23
4		3.13	4.10	4.88	3.03	2.03	2.22
5	2.55	3.34	4.09	4.80	2.88	2.11	2.21
6	2.60	3.30	4.22	4.87	2.88	2.16	2.19
7	2.62	2.80	4.40	4.83	2.90	2.00	2.30
8	2.67	2.80	4.35	4.82	2.84	2.10	2.20
9	2.68	2.74	4.25	4.70	2.75	2.12	2.28
10	2.58	2.80	4.21	4.50	2.85	2.16	2.25
11	2.55	2.73	4.02	4.45	2.95	2.11	2.28
12	2.54	2.87	3.97	4.40	2.91	2.02	2.22
13	2.86	2.99	4.02	4.25	3.08	2.03	2.20
14	3.26	3.02	4.08	4.14	2.81	2.15	2.28
15	3.76	3.19	4.22	4.20	2.74	2.13	2.34
16	3.70	3.40	4.45	(*a*)	2.84	2.15	2.35
17	3.58	3.61	4.48	(*a*)	2.82	2.17	2.30
18	3.58	3.74	4.25	(*a*)	2.77	2.18	2.35
19	3.60	3.87	4.10	4.00	2.70	2.21	2.32
20	3.65	4.06	(*f*)	3.93	2.68	2.23	2.35
21	3.50	4.19	(*f*)	3.80	2.60	2.21	2.40
22	3.43	4.32	4.80	3.75	2.62	2.19	.....
23	3.15	4.23	4.95	3.65	2.58	2.22	.....
24	3.08	4.19	5.08	3.50	2.55	2.40	.....
25	3.05	4.30	5.30	3.48	2.58	2.30	.....
26	3.05	4.03	5.35	3.32	2.48	2.23	.....
27	3.20	3.85	5.20	3.20	2.47	2.20	.....
28	3.55	3.75	5.00	3.20	2.48	2.30	.....
29	3.65	3.80	4.85	3.07	2.47	2.22	.....
30	3.75	3.92	4.85	2.93	2.35	2.25	.....
31	.....	4.03	.....	3.04	2.34	.....	.....

Discontinued October 31. *a* Bridge out. *f* Rod out.

NORTH PLATTE RIVER AT NORTH PLATTE, NEBRASKA.

The lowest gaging station on this river is located at the wagon bridge at North Platte, Nebraska, and was established in 1894. It is 3.5 miles above the junction of the South Platte River. The bridge is a long, low, pile bridge, having 93 spans of approximately 20 feet each, crossing the main channel of the river. North of this is another bridge crossing a slough, through which no water passes, however, *except in* time of flood. The gage rod is at the railroad bridge 2 miles

below the wagon bridge. The zero is 12 feet below the top and imme diately under the east rail of the track. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 158; 1897, Nineteenth Annual Report, Part IV, page 309; 1898, Twentieth Annual Report, Part IV, page 269. The following discharge measurements were made by Glenn E. Smith and Charles P. Ross during 1899:

Measurements of North Platte River at North Platte, Nebraska.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
Apr. 19	3.30	9,111	July 17	3.30	10,351
May 6	3.00	8,239	Aug. 8	2.50	4,637
May 22	3.80	12,962	Aug. 28	1.85	2,013
June 6	3.60	13,310	Sept. 15	1.55	976
June 15	3.60	11,330	Oct. 4	1.70	713
June 19	4.20	16,257			

Daily gage height, in feet, of North Platte River at North Platte, Nebraska, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.70	3.00	3.00	2.30	3.50	3.55	4.10	2.60	1.90	1.55	1.90	2.10
2	2.70	3.00	3.00	2.10	3.50	3.70	4.20	2.70	1.80	1.50	2.00	2.10
3	2.70	3.00	3.00	2.80	3.40	3.80	4.15	2.70	1.80	1.60	2.00	2.05
4	2.70	3.00	3.00	2.70	3.25	3.80	4.10	2.80	1.80	1.70	2.05	2.05
5	2.70	3.00	3.00	2.60	3.15	3.70	4.10	2.80	1.65	1.70	2.10	2.30
6	2.70	3.00	3.00	2.80	3.00	3.60	4.10	2.70	1.65	1.70	2.15	2.50
7	2.70	3.00	3.00	2.85	3.00	3.65	4.00	2.65	1.70	1.70	2.10	2.50
8	2.70	3.00	3.00	2.55	3.25	3.80	4.00	2.50	1.70	1.60	2.10	2.50
9	2.70	3.00	3.00	2.50	3.15	3.90	4.00	2.50	1.60	1.60	2.10	2.40
10	2.70	3.00	3.10	2.50	2.80	3.90	4.00	2.40	1.55	1.60	2.10	2.40
11	2.70	3.00	3.10	2.50	2.75	3.85	3.90	2.30	1.60	1.60	2.10	2.40
12	2.70	3.00	3.10	2.60	2.60	3.75	3.65	2.30	1.60	1.70	2.10	2.40
13	2.70	3.00	3.10	2.65	2.60	3.65	3.60	2.35	1.60	1.70	2.00	2.40
14	2.70	3.00	3.10	2.50	2.50	3.55	3.60	2.50	1.60	1.65	2.00	2.40
15	2.70	3.00	3.10	2.45	2.60	3.60	3.55	2.50	1.55	1.80	2.05	2.40
16	2.70	3.00	3.10	2.50	2.65	3.70	3.40	2.40	1.50	1.80	2.10	2.40
17	2.70	3.00	3.00	3.25	2.85	3.95	3.30	2.35	1.50	1.80	2.05	2.40
18	2.70	3.00	2.80	3.30	3.05	4.00	3.20	2.40	1.50	1.80	2.00	2.40
19	2.80	3.00	2.80	3.35	3.05	4.20	3.25	2.30	1.50	1.80	2.10	2.40
20	2.80	3.00	2.80	3.40	3.40	4.15	3.30	2.30	1.50	1.80	2.10	2.40
21	2.80	3.00	2.50	3.30	3.60	3.95	3.30	2.30	1.60	1.80	2.20	2.40
22	2.90	3.00	2.80	3.10	3.75	3.85	3.20	2.00	1.60	1.80	2.20	2.40
23	2.80	3.00	2.80	3.10	3.75	3.90	3.15	2.00	1.50	1.80	2.10	2.40
24	2.80	3.00	3.05	3.10	3.80	3.85	3.00	1.90	1.50	1.80	2.10	2.45
25	3.00	3.00	2.90	3.00	3.70	4.15	2.95	1.90	1.50	1.80	2.10	2.55
26	3.00	3.00	2.60	2.90	3.80	4.30	2.80	1.90	1.60	1.90	2.10	2.70
27	3.00	3.00	2.60	3.00	3.85	4.45	2.80	1.90	1.60	2.00	2.10	2.70
28	3.00	3.00	2.55	3.00	3.85	4.40	2.85	1.85	1.55	2.00	2.20	2.70
29	3.00	.....	2.50	3.00	3.75	4.30	2.70	1.75	1.60	2.00	2.10	2.70
30	3.00	.....	2.55	3.10	3.50	4.25	2.70	1.65	1.60	2.00	2.10	2.70
31	3.00	.....	2.60	.....	3.50	.....	2.55	1.75	.....	1.95	.....	2.65

SOUTH PLATTE RIVER.

The headwater tributaries of this stream have their sources in the high mountain peaks surrounding the basin known as South Park. The average elevation of the valley is 8,000 feet, while the peaks attain an elevation of 13,000 feet. Considerable irrigation is practiced on a small scale, but principally for forage crops, as on account of the high altitude only the hardier products can be raised. The

streams have a general northerly direction, and upon issuing from the mountainous area the water is quickly appropriated by the large irrigation enterprises serving land on both sides of the South Platte River in the vicinity of Denver. A number of smaller streams rising on the eastern slope of the Rocky Mountains drain easterly into the South Platte River. The principal tributaries are—in order downstream—Bear Creek, Clear Creek, South Boulder Creek, Boulder Creek, St. Vrain Creek, Big Thompson Creek, and Cache la Poudre River. Gaging stations have been maintained on them also as well as one at Lake Cheesman on the South Fork of South Platte, and one on Goose Creek, which also contributes to the supply of the proposed reservoir. The next one downstream on the main river is at Platte Canyon, the third one at Denver, and the lower one at Orchard, Colorado. Besides the measurements of discharge at regular stations a number of others have been made in this basin during 1899, as follows: April 14 a measurement of the High-line ditch in the South Platte, at a gage height of 1.20 feet, showed a discharge of 98 second-feet. On July 28 the same canal was measured twice, the first time at a gage height of 3.25 feet, showing a discharge of 432 second-feet; the second time at a gage height of 3 feet, with a discharge of 375 second-feet. On the same day also the South Platte River was discharging over the High-line dam, at a gage height of 0.50 foot, 73 second-feet. September 14, South Platte River, at Julesburg, was carrying 2 second-feet. October 4 the river at the dam of the High-line canal, at a gage height of 0.13 foot, was discharging 12 second-feet.

A notable storage proposition on which work was prosecuted during the past season is that of the dam of Lake Cheesman, which is located on the South Fork of South Platte River, below the mouth of Goose Creek. The dam, which is partially completed, will be 215 feet high. Its length at its base is only 20 feet and at the top it will be 520 feet. The abutments are solid granite. The main tunnel for diverting the flow during the course of the construction of the dam is now completed, and work is now progressing on two subsidiary tunnels. The dam is to be rock filled and steel plate faced. The capacity of the reservoir is about 90,000 acre-feet. The object of this enterprise is to develop electric power to be used in the city of Denver, and also to furnish a water supply for the same city.

GOOSE CREEK AT LAKE CHEESMAN, COLORADO.

The station on this creek, a tributary of South Platte River, was established August 1, 1899, by J. A. Runner, assistant engineer of the Denver Union Water Company. It was desired to obtain the flow of the South Fork of South Platte River at this point, where the construction of the Cheesman dam has been begun, the discharge of Goose Creek being added to the South Fork of South Platte to give

ıe total flow at this point. The station is maintained by the Denver 'nion Water Company. All discharge measurements for 1899 have een made by means of floats. This station is to be considered simly as temporary, as it will be necessary to move it farther upstream 'hen water is stored in the reservoir. The following discharge ıeasurements were made by J. A. Runner during 1899:

September 8, gage height, 0.95 foot; discharge, 24 second-feet.
October 8, gage height, 0.84 foot; discharge, 10 second-feet.
November 19, gage height, 0.72 foot; discharge, 8 second-feet.
December 3, gage height, 0.76 foot; discharge, 9 second-feet.

Daily gage height, in feet, of Goose Creek at Lake Cheesman, Colorado, for 1899.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.25	0.97	0.85	.....	0.80	17	1.04	.90	.86	.....	.....
2	1.20	.95	.85	.....	.....	18	1.00	.89	.86	.85	.74
3	1.30	*a* .95	.85	.....	.76	19	.98	.88	.87	.....	.....
4	1.32	*a* .95	.85	0.85	.....	20	.96	.88	.87	.....	.80
5	1.35	*a* .95	.86	.....	.74	21	.96	.88	.88	.84	.....
6	1.15	*a* .95	.85	.86	.....	22	.95	.88	.88	.....	.....
7	1.25	*a* .95	.85	.....	.....	23	.94	*a* .88	.88	.....	.....
8	1.25	.95	.84	.87	.....	24	.93	*a* .88	.....	.82	.....
9	1.10	.94	.84	.87	.....	25	.93	*a* .88	.....	.....	.....
10	1.09	.94	.85	.....	.72	26	.92	.87	.....	.80	.....
11	1.06	.92	.85	.87	.....	27	.91	.87	.....	.....	.....
12	1.05	.90	.85	.....	.73	28	.90	.86	.....	.....	.....
13	1.05	.89	.85	.....	.....	29	.91	.86	.....	.80	.....
14	1.05	.88	.85	.86	.74	30	.93	.85	.....	.....	.....
15	1.04	.89	.85	.....	.....	31	.96	.....	.....	.....	.....
16	1.04	.90	.85	.85	.73						

a Estimated.

OUTH FORK OF SOUTH PLATTE RIVER AT LAKE CHEESMAN, COLORADO.

This station was established July 31, 1899, and has been maintained ince that time by the Denver Union Water Company, J. A. Runner, assistant engineer, making the discharge measurements. It is ocated above the mouth of Goose Creek, and is maintained in order o determine the flow available for Lake Cheesman. The discharge ere should be added to the discharge of Goose Creek, as the dam or this reservoir is located below the mouth of the latter tributary. It will be necessary in this case, as in the preceding one, to ıove the station upstream when water has been stored in the reservoir, so the station can be considered merely as a temporary one. It s the intention that both the inflow and the discharge from the reservoir shall be accurately measured after the storage has begun. The ollowing measurements of discharge were made by J. A. Runner by ıeans of floats in 1899:

July 31, gage height, 3.62 feet; discharge, 806 second-feet.
September 8, gage height, 1.45 feet; discharge, 184 second-feet.
October 3, gage height, 1.23 feet; discharge, 95 second-feet.
November 19, gage height, 1.30 feet; discharge, 107 second-feet.
December 3, gage height, 1.24 feet; discharge, 97 second-feet.

Daily gage height, in feet, of South Platte River at Lake Chamberlain, Colorado, for 1899.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.25	1.55	1.35		1.20	17	1.75	1.30	1.30		
2	2.20	1.50	1.35			18	1.75	1.30	1.25	1.25	1.0
3	2.00	(a)	1.35		1.35	19	1.65	1.25	1.25	1.20	
4	1.75	(a)	1.35	1.20		20	1.60	1.20	1.25		1.10
5	1.55	(a)	1.30		1.30	21	1.55	1.25	1.20		
6	1.50	(a)	1.05	1.40		22	1.50	1.30	1.25	1.25	
7	2.00	(a)	.90			23	1.50	(a)	1.25		1.15
8	2.00	1.65	.95	1.45		24	1.60	(a)		1.20	
9	2.35	1.65	.95	1.40		25	1.50	(a)			
10	2.15	1.60	.90		.90	26	1.50	(a)		.90	
11	2.00	1.40	.90	1.40		27	1.60	1.35			
12	1.95	1.40	.90		.90	28	1.60	1.25			
13	1.90	1.30	.90			29	1.60	1.35		1.30	
14	1.85	1.30	1.10	1.40	.90	30	1.60	1.35			
15	1.70	1.30	1.40			31	1.60				
16	1.70	1.30	1.40	1.20	1.00						

a No readings.

SOUTH PLATTE RIVER AT PLATTE CANYON, COLORADO.

This station has been maintained for sometime by the Denver Union Water Company, but cooperation with this Survey was not begun until April 1, 1899. The station is located at a point about 2 miles above Platte Canyon railway station, on the Colorado and Southern Railroad. The rod is an inclined 2 by 6 timber on the right-hand side of the stream, marked with brass nails. The bench mark is a point chiseled in a circle just south of the Denver Union Water Company's pipe line, and 15 feet south of the zero point of soundings on the bridge. It is on a granite rock and is 10 feet above gage datum. Measurements of discharge are made from the footbridge constructed by the Denver Union Water Company. The channel of the stream is rocky, and at first it was considered that it was not liable to material change; but during a freshet of considerable size erosion took place, making necessary a change in the rating table. This station gives the total discharge of the river at Platte Canyon before any water is taken out for irrigation or any other purposes excepting that taken out by the Denver Union Water Company at a point about 1 mile above the station. The observer, G. E. Carleton, Littleton, Colorado, is superintendent of the filtering plant belonging to the Denver Union Water Company. He furnishes gage readings to the United States Weather Bureau at Denver, where they are published each day. The following discharge measurements were made under the direction of A. L. Fellows during 1899:

April 14, 1899, gage height, 1.8 feet; discharge, 559 second-feet.
May 8, 1899, gage height, 1.5 feet; discharge, 500 second-feet.
June 10, 1899, gage height, 2.9 feet; discharge, 1,127 second-feet.
July 28, 1899, gage height, 1.8 feet; discharge, 633 second-feet.
October 4, 1899, gage height, 0.1 feet; discharge, 146 second-feet.

gage height, in feet, of South Platte River at Platte Canyon, Colorado, for 1899.

Day.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	0.50	1.40	2.50	3.20	2.50	0.90	0.10	0.40	—0.10
.....	.50	1.50	2.50	3.80	2.20	.90	.00	.30	— .40
.....	.55	1.50	2.50	4.10	2.60	.90	.00	.40	— .40
.....	.60	1.20	2.60	4.10	3.30	.80	.00	.40	—1.10
.....	.60	1.10	2.40	3.90	3.30	.70	.10	.40	-1.80
.....	.50	1.10	2.40	3.60	2.90	.00	.10	.40	— .60
.....	.60	1.20	2.50	3.40	2.70	.60	.10	.30	— .60
.....	.60	1.50	2.80	3.40	2.50	.60	—.20	.40	.70
.....	.70	1.90	3.00	3.30	2.30	.60	—.30	.40	— .30
.....	.70	2.10	2.90	3.10	2.00	.60	—.30	.30	— .40
.....	.80	2.20	3.00	2.80	1.80	.60	—.20	.30	— .20
.....	1.20	2.30	3.20	2.70	1.60	.50	—.20	.30	.10
.....	1.50	2.50	3.30	2.70	1.60	.50	—.10	.30	.30
.....	1.80	2.60	3.50	3.00	1.60	.50	—.10	.30	.00
.....	1.90	2.60	3.40	3.00	1.50	.50	.20	.20	.30
.....	1.70	2.70	3.50	3.00	1.40	.50	.20	.30	.60
.....	1.80	2.60	3.50	3.20	1.40	.50	.30	.10	.70
.....	2.00	2.60	3.50	3.30	1.30	.50	.40	.10	.50
.....	1.80	2.50	3.50	3.10	1.20	.50	.40	.00	.50
.....	1.70	2.50	4.65	3.00	1.10	.50	.30	—.20	.50
.....	1.40	2.40	4.20	2.60	1.00	.40	.30	.10	.60
.....	1.40	2.30	4.20	2.40	1.00	—.10	.30	.00	.60
.....	1.50	2.30	3.90	2.20	.90	+.20	.20	.20	.60
.....	1.60	2.40	3.60	2.10	.80	.50	.20	.20	.60
.....	1.80	2.40	3.60	2.00	.80	.20	.30	—.20	.50
.....	2.10	2.50	3.70	1.90	.70	.30	.30	—.40	.40
.....	1.90	2.50	3.60	1.90	.70	.20	.30	—.60	.20
.....	1.90	2.50	3.40	1.80	.70	.20	.30	—.30	.30
.....	1.70	2.50	3.30	2.20	.70	.10	.30	.10	.30
.....	1.60	2.50	3.20	2.80	.70	.10	.30	—.10	.30
.....	.....	2.50	.....	3.10	1.10	.....	.30	.....	.40

SOUTH PLATTE RIVER AT DENVER, COLORADO.

e gaging station at this point, established July 15, 1895, is located e Fifteenth street bridge in the city of Denver, immediately below outh of Cherry Creek. The rod at present used is fastened to a in the left bank of the river and graduated to vertical feet and s. The bench mark is a cross on top of east abutment of the enth street bridge on the north corner, and is 15.15 feet above datum. The river is confined between slag embankments, and ed, although sandy and shifting, did not materially change dur- 899. Mr. W. J. Southland, water commissioner of Colorado ation District No. 2, cooperated with this survey in furnishing age readings, which are also transmitted to the United States her Bureau, and published each day in the Denver daily papers. station is an important one, and it is fortunate that it can so be reached and discharge measurements made without great ise. Results of measurements may be found as follows: 1896, eenth Annual Report, Part IV, page 165; 1897, Nineteenth al Report, Part IV, page 313; 1898, Twentieth Annual Report, IV, page 279. The following measurements of discharge were by A. L. Fellows in 1899:

April 12, gage height, 6.0 feet; discharge, 422 second-feet.
May 11, gage height, 6.03 feet; discharge, 355 second-feet.
June 12, gage height, 6.2 feet; discharge, 764 second-feet.
July 27, gage height, 5.32 feet; discharge, 213 second-feet.
August 4, gage height, 6.93 feet; discharge, 1,200 second-feet.
September 6, gage height, 5.95 feet; discharge, 288 second-feet.
October 5, gage height, 5.1 feet; discharge, 100 second-feet.

Daily gage height, in feet, of South Platte River at Denver, Colorado, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.80	4.80	6.10	6.10	5.85	5.90	6.30	6.20	6.00	5.20	5.15	5.55
2	4.70	4.80	6.00	6.05	5.85	5.90	6.65	5.95	5.95	5.20	5.25	5.65
3	4.80	4.80	6.00	6.00	5.75	6.10	6.95	5.90	6.00	5.15	5.35	5.15
4	4.90	4.80	5.90	5.95	5.75	5.90	7.10	7.00	6.00	5.10	5.40	5.25
5	4.90	4.90	5.90	5.90	5.80	6.00	7.00	7.20	5.90	5.10	5.30	5.35
6	4.80	4.90	5.80	5.80	5.95	5.95	6.60	6.95	5.85	5.10	5.25	5.50
7	4.90	4.80	5.80	5.75	5.85	6.30	6.45	6.75	5.80	5.05	5.35	5.50
8	4.90	4.70	5.70	5.80	5.75	6.50	6.40	6.60	5.80	4.90	5.40	5.15
9	4.80	4.80	5.60	5.90	5.75	6.50	6.40	6.45	5.80	4.90	5.25	5.15
10	4.70	4.90	5.50	6.05	6.05	6.45	6.35	6.30	5.80	5.00	5.20	5.30
11	4.80	4.80	5.60	6.15	6.05	6.25	6.15	6.20	5.75	5.00	5.40	5.05
12	4.80	4.90	5.70	6.10	6.10	6.25	6.00	6.20	5.75	5.00	5.70	5.15
13	4.90	5.10	5.60	6.15	6.25	6.45	5.95	6.00	5.70	5.10	5.60	5.15
14	5.00	5.20	5.80	6.20	6.25	6.50	6.40	6.00	5.65	5.20	5.50	5.05
15	4.90	5.30	5.80	6.25	6.35	6.65	6.25	6.00	5.70	5.20	5.55	5.20
16	4.90	5.30	5.90	6.30	6.30	6.60	6.30	5.90	5.75	5.25	5.45	5.30
17	4.80	5.40	6.00	6.20	6.25	6.65	6.40	5.65	5.80	5.15	5.55	5.25
18	4.90	5.70	6.10	6.35	6.20	6.65	6.45	5.65	5.75	5.05	5.35	5.30
19	4.80	6.30	6.15	6.25	6.08	6.65	6.60	5.55	5.75	5.15	5.45	5.35
20	4.80	6.20	6.25	6.05	6.08	6.85	6.30	5.65	5.80	5.20	5.70	5.25
21	4.80	6.00	6.30	5.95	6.00	7.10	6.20	6.05	5.70	5.10	5.65	5.25
22	4.70	5.90	6.20	5.95	5.90	7.00	6.00	6.02	5.65	5.15	5.75	5.25
23	4.80	5.70	6.05	5.95	5.80	6.90	5.90	5.98	5.60	5.25	5.70	5.30
24	4.70	5.60	6.00	6.00	5.88	6.90	5.80	5.92	5.30	5.30	5.70	5.35
25	4.80	5.50	5.90	5.95	5.80	6.80	5.70	5.85	5.60	5.20	5.60	5.40
26	4.90	5.60	5.95	6.10	5.85	6.70	5.60	5.75	5.60	5.20	5.65	5.40
27	4.80	5.80	6.05	6.15	5.88	6.65	5.50	5.65	5.60	5.30	5.65	5.25
28	4.70	6.20	6.10	6.05	5.95	6.55	5.30	5.75	5.65	5.25	5.70	5.30
29	4.80	.....	6.20	5.95	6.30	6.40	5.20	5.80	5.50	5.15	5.60	5.40
30	4.80	.....	6.15	5.90	5.95	6.30	5.90	5.90	5.20	5.25	5.50	5.20
31	4.80	.....	6.10	.....	5.85	.....	6.10	6.00	.....	5.15	.....	5.40

SOUTH PLATTE RIVER AT ORCHARD, COLORADO.

This station, on the lower South Platte River, is located one-fourth of a mile southwest of Orchard, Colorado. The gage is vertical and is fastened to a pile of the wagon bridge. The gage rod is not referred to any satisfactory bench mark, and consequently when the pile to which the rod was nailed was raised a number of tenths by ice about March 17, it was necessary that a new rating table be made for observations after that date. The left bank is high and the right low and liable to overflow. The bed of the stream is sandy and shifting, although the section did not materially change during 1899. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 166; 1897, Nineteenth Annual Report, Part IV, page 315; 1898, Twentieth Annual Report, Part IV, page 293. The following measurements of discharge were made under the direction of A. L. Fellows in 1899:

April 14, gage height, 3.2 feet: discharge, 1,258 second-feet.
May 27, gage height, 2.3 feet: discharge, 158 second-feet.
September 12, gage height, 2.05 feet: discharge, 57 second-feet.
November 3, gage height, 2.80 feet: discharge, 614 second-feet.

gage height, in feet, of South Platte River at Orchard, Colorado, for 1899.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
..	4.50	4.40	5.00	3.20	3.20	2.10	3.40	2.80	2.00	2.30	2.80	3.00
..	4.50	4.40	5.00	3.20	3.20	2.10	3.45	2.75	2.00	2.30	2.80	3.00
..	4.50	4.40	5.00	3.20	3.10	2.10	3.70	2.70	1.90	2.30	2.80	3.00
..	4.50	4.40	5.00	3.20	3.10	2.10	3.90	2.70	1.90	2.30	2.80	3.00
	4.50	4.40	5.00	3.20	3.10	2.00	4.20	2.90	1.90	2.30	2.80	3.00
..	4.50	4.40	5.00	3.20	3.00	2.00	4.00	4.20	1.90	2.30	2.80	3.00
..	4.50	4.40	4.80	3.20	3.00	2.00	3.80	4.20	1.90	2.30	2.80	3.00
..	4.40	4.40	4.80	3.20	3.00	2.00	3.90	4.00	1.90	2.30	2.80	3.00
..	4.40	4.40	4.50	3.20	3.00	1.90	4.20	3.80	1.90	2.30	2.85	3.00
..	4.40	4.40	4.50	3.20	2.80	1.90	4.00	3.70	1.90	2.35	2.85	3.00
..	4.40	4.40	4.50	3.20	2.80	1.90	3.50	3.40	1.90	2.40	2.90	3.00
..	4.40	4.40	4.50	3.20	2.80	1.85	3.20	3.20	1.90	2.50	2.90	3.00
..	4.40	4.45	4.50	3.20	2.50	1.90	3.00	3.20	1.90	2.60	2.90	3.20
..	4.40	4.50	4.50	3.20	2.50	3.00	3.10	3.20	1.90	2.70	2.90	3.20
..	4.40	4.60	4.00	3.20	2.50	3.20	3.20	2.70	1.90	2.80	2.90	3.20
..	4.40	4.70	4.00	3.20	2.50	3.20	3.50	2.65	1.90	2.80	2.90	3.20
..	4.40	4.75	4.00	3.20	2.50	3.20	3.80	2.60	1.90	2.80	2.95	3.20
..	4.40	4.80	3.50	3.25	2.30	3.20	3.90	2.50	1.90	2.80	2.98	3.20
..	4.40	4.80	3.20	3.30	2.30	3.20	4.00	2.40	1.90	2.80	3.00	3.30
..	4.40	5.00	3.20	3.30	2.20	3.20	3.70	2.40	1.95	2.80	3.00	3.40
..	4.40	5.00	3.20	3.30	2.20	3.90	3.60	2.35	1.95	2.80	3.00	3.60
..	4.40	5.00	3.20	3.30	2.20	4.40	3.30	2.30	2.00	2.80	3.00	3.70
..	4.40	5.00	3.20	3.30	2.20	4.50	3.20	2.30	2.00	2.80	3.00	3.80
..	4.40	5.00	3.20	3.30	2.20	4.60	3.00	2.20	2.10	2.80	3.00	3.90
..	4.40	5.00	3.20	3.30	2.20	4.20	2.90	2.15	2.10	2.80	3.00	3.90
..	4.40	5.00	3.20	3.30	2.20	4.10	2.85	2.10	2.20	2.80	3.00	3.90
..	4.40	5.00	3.20	3.30	2.20	4.00	2.70	2.00	2.20	2.80	3.00	4.00
..	4.40	5.00	3.20	3.30	2.20	3.90	2.60	2.00	2.20	2.80	3.00	4.00
..	4.40	.....	3.20	3.30	2.20	3.70	2.60	2.00	2.30	2.80	3.00	4.00
..	4.40	.....	3.20	3.30	2.20	3.60	2.50	2.00	2.30	2.80	3.00	4.00
..	4.40	.....	3.20	.....	2.20	.....	2.80	2.00	.....	2.80	.....	4.00

water diversions from this stream in Colorado are so extensive uring the summer season a comparatively insignificant flow s Nebraska. Measurements of the South Platte were made s junction with the North Platte. On April 19, 1899, Glenn E. made a measurement from the wagon bridge south of the town th Platte, and found the total width to be 1,296 feet, while the ge was 883 second-feet; on May 6 the discharge was 866 second- nd on May 22, 88 second-feet. At this time the water was flow- a number of small channels scattered across the sandy bed. ne 6 the channel was dry.

BEAR CREEK AT MORRISON, COLORADO.

stream, a tributary of the South Platte, drains a portion of the slope of the Rocky Mountains and enters the main stream 8 bove Denver. The station is located in the upper part of the f Morrison. The present station was established April 16, 1899, n E. Field, State engineer, and is located about a quarter of a bove the railway station. The gage rod consists of a 2 by 4 placed vertically and marked in feet and tenths, and is fas- o the upper side of the dam which diverts water into the mains Denver Union Water Company. At the height of 4 feet on the od water begins to flow over the spillway, making a marked nce in the rating curve. The bench mark consists of the top anite bowlder about 100 feet above the rod and on the left-hand the stream, and is 10.33 feet above gage datum. The station aintained during the year through cooperation with the Denver Water Company. Previous results of measurements may be

found as follows: 1896, Eighteenth Annual Report, Part IV, page 167; 1897, Nineteenth Annual Report, Part IV, page 317; 1898, Twentieth Annual Report, Part IV, page 284. The following discharge measurements were made under the direction of A. L. Fellows during 1899:

April 15, gage height, 3.80 feet; discharge, 64 second-feet.
May 9, gage height, 4.25 feet; discharge, 99 second-feet.
June 16, gage height, 4.25 feet; discharge, 107 second-feet.
August 5, gage height, 4.98 feet; discharge, 192 second-feet.
November 14, gage height, 1.35 feet; discharge, 13 second-feet.

Daily gage height, in feet, of Bear Creek at Morrison, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	4.05	4.05	4.15	4.10	3.35	2.00
2	.....	4.10	4.05	4.40	4.15	3.35	1.90
3	.....	3.20	3.95	4.45	5.25	3.25	1.90
4	.....	3.25	3.85	4.45	5.80	3.25	1.90
5	.....	3.55	3.55	4.20	5.20	3.15	1.80
6	.....	3.65	3.90	4.05	5.05	2.95	1.80
7	.....	3.90	4.20	4.20	4.90	2.80	1.80
8	.....	4.15	4.15	4.20	4.75	2.65	1.80
9	.....	4.20	4.30	4.05	4.65	2.65	1.80
10	.....	4.20	4.15	3.75	4.65	2.55	2.20
11	.....	4.40	4.15	3.65	4.55	2.70	2.10
12	.....	4.55	4.20	3.65	4.55	2.75	2.10
13	.....	4.60	4.30	4.10	4.45	2.70	2.00
14	.....	4.70	4.25	4.25	4.35	2.65	2.00
15	.....	4.70	4.15	4.30	4.25	2.60	2.05
16	4.20	4.65	4.15	4.30	4.15	2.70	2.00
17	4.20	4.60	4.15	4.50	4.20	2.75	1.95
18	4.15	4.50	4.15	4.10	3.95	2.65	1.90
19	4.15	4.45	4.25	4.00	3.75	2.60	1.80
20	3.95	4.45	4.20	4.00	3.65	2.45	1.80
21	3.75	4.25	4.25	3.95	3.45	2.45	1.70
22	4.00	4.25	4.25	3.90	3.35	2.35	.....
23	4.05	4.25	4.15	3.85	3.25	2.25	.....
24	4.20	4.25	4.15	3.75	3.15	2.20	.....
25	4.20	4.25	4.30	3.65	3.05	2.20	.....
26	4.10	4.25	4.15	3.75	3.05	2.15	.....
27	4.10	4.25	4.15	3.75	2.95	2.10	.....
28	4.00	4.25	4.05	3.75	2.75	2.10	.....
29	3.85	4.15	4.05	4.25	2.55	2.05	.....
30	3.65	4.15	4.20	4.15	2.45	2.00	.....
31	.....	4.15	.....	3.90	3.35	.....	.....

Closed for the winter October 21.

CLEAR CREEK AT FORKSCREEK, COLORADO.

This stream rises on the eastern slope of the Rocky Mountains almost due west of Denver, and flows in an easterly direction, entering the South Platte River 6 miles below the center of the city of Denver. The small summer flow of this stream is completely utilized for irrigation purposes. The gaging station, established by John E. Field, State engineer, March 29, 1899, is located at the railway station at Forkscreek, on the Colorado and Southern Railway, in Clear Creek Canyon, just below the junction of the North and South forks. The gage consists of a weight fastened to a wire running over a pulley fastened to a rock at the railway station. Bench mark No. 1 is a point on the timber to which the pulley is attached, and is 13.58 feet above gage datum. Bench mark No. 2 is a granite point 49.5 feet east of the first bench mark, and is 15.46 feet above gage datum. The channel is rocky and not liable to serious change. The walls are high and not liable to overflow. On April 20 measurements of the North and

outh forks were made separately and gave 43 second-feet and 101 econd-feet, respectively. The following discharge measurements ere made under the direction of A. L. Fellows during 1899:

March 29, gage height, 1.50 feet; discharge, 52 second-feet.
April 20, gage height, 2.10 feet; discharge, 155 second-feet.
May 10, gage height, 2.75 feet; discharge, 365 second-feet.
June 7, gage height, 3.70 feet; discharge, 779 second-feet.
August 12, gage height, 3.08 feet; discharge, 449 second-feet.
November 15, gage height, 1.70 feet; discharge, 67 second-feet.

Daily gage height, in feet, of Clear Creek at Forkscreek, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.65	2.55	(a)	4.45	3.35	2.60	2.10	2.10	1.40
2	1.75	2.50	(a)	4.40	3.30	2.75	2.10	2.05	1.40
3	1.65	2.50	(a)	4.30	3.35	2.60	2.10	2.00	.....
4	1.65	2.25	(a)	4.05	3.40	2.60	2.00	2.00	.....
5	1.70	2.35	(a)	4.00	3.55	2.60	2.00	1.90	.....
6	1.55	2.40	(a)	4.05	3.35	2.50	2.00	1.85	.....
7	1.75	2.45	3.70	4.00	3.30	2.40	2.00	1.75	.....
8	1.70	2.45	3.75	4.00	3.30	2.40	2.00	1.75	.....
9	1.85	2.60	3.80	3.95	3.25	2.30	2.00	1.80	.....
10	1.95	2.85	3.80	3.90	3.15	2.30	2.00	1.80	.....
11	2.20	3.10	3.90	3.75	3.10	2.30	2.00	1.80	.....
12	2.20	3.50	4.15	3.70	3.05	2.30	2.00	1.80	.....
13	2.05	3.75	4.30	3.70	3.00	2.30	2.10	1.80	.....
14	2.15	4.00	4.40	3.70	3.00	2.30	2.05	1.80	.....
15	2.20	4.10	4.20	3.70	3.00	2.30	2.10	1.70	.....
16	2.30	4.25	4.25	3.70	3.00	2.30	2.10	1.70	.....
17	2.30	4.20	4.30	3.70	2.95	2.30	2.10	1.70	.....
18	2.30	4.35	4.45	3.60	2.90	2.30	2.10	1.65	.....
19	2.15	4.45	4.65	3.50	2.85	2.20	2.10	1.60	.....
20	2.10	(a)	4.70	3.50	2.80	2.20	2.00	1.55	.....
21	2.20	(a)	4.75	3.50	2.75	2.20	2.00	1.50	.....
22	2.20	(a)	4.70	3.50	2.70	2.20	2.00	1.55	.....
23	2.45	(a)	4.40	3.50	2.70	2.20	2.00	1.65	.....
24	2.50	(a)	4.40	3.40	2.70	2.20	2.00	1.50	.....
25	2.75	(a)	4.25	3.40	2.70	2.20	2.00	1.40	.....
26	2.90	(a)	4.25	3.40	2.70	2.20	2.05	1.40	.....
27	2.80	(a)	4.15	3.40	2.70	2.20	2.10	1.40	.....
28	2.80	(a)	4.10	3.40	2.60	2.10	2.00	1.40	.....
29	2.30	(a)	4.10	3.45	2.60	2.10	2.00	1.40	.....
30	2.45	(a)	4.25	3.40	2.60	2.10	2.00	1.40	.....
31	.....	(a)	.....	3.40	2.60	.....	2.05	.....	.....

a Gage broken; no reading.

SOUTH BOULDER CREEK AT MARSHALL, COLORADO.

This stream, the next one of importance entering below Clear Creek, is measured at a point about 3 miles west of Marshall, Colorado. The gage is an inclined 2 by 6 inch timber fastened to a tree and stakes driven into the ground. The bench mark is a stone 15 feet west of the gage, marked with black paint, and is 6.99 feet above gage datum. The gage was verified August 10, 1899. Two ditches divert water at points above the station, viz, the South Boulder and Coal Creek ditch and the Community ditch, and their discharge must be added to the discharge as found at the station to determine the total run-off of the basin. May 6 South Boulder and Coal Creek ditch, at a gage height of 0.7 foot, was discharging 7 second-feet, and on the same date Community ditch, at a gage height of 2.25 feet, was carrying 35 second-feet. C. E. Barber, Langford, Colorado, is the observer. Measurements are usually made by wading, but a footbridge near by can be used in high water. Results of measurements may be found as fol-

lows: 1896, Eighteenth Annual Report, Part IV, page 169; 1897, Nineteenth Annual Report, Part IV, page 318; 1898, Twentieth Annual Report, Part IV, page 287. The following discharge measurements were made under the direction of A. L. Fellows in 1899:

April 22, gage height, 1.70 feet; discharge, 115 second-feet.
May 6, gage height, 1.55 feet; discharge, 96 second-feet.
June 15, gage height, 2.80 feet; discharge, 451 second-feet.
August 10, gage height, 1.60 feet; discharge, 109 second-feet.
October 10, gage height, 0.70 foot; discharge, 7 second-feet.

Daily gage height, in feet, of South Boulder Creek at Marshall, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1	0.90	1.80	2.50	2.65	1.65	1.30	17	1.75	2.65	2.85	2.15	1.40	1.10
2	1.00	1.80	2.55	2.65	1.55	1.30	18	1.75	2.60	2.90	2.10	1.40	1.10
3	.95	1.65	2.50	2.55	1.65	1.30	19	1.80	2.65	2.95	2.10	1.40	1.10
4	1.00	1.65	2.35	2.45	1.85	1.25	20	1.80	2.65	3.00	2.00	1.35	1.00
5	.95	1.60	2.30	2.45	2.00	1.20	21	1.80	2.50	3.00	2.05	1.30	1.05
6	1.00	1.60	2.35	2.40	1.90	1.20	22	1.85	2.45	3.00	2.00	1.30	.90
7	.95	1.65	2.45	2.35	1.80	1.20	23	1.80	2.35	2.85	2.00	1.35	.90
8	1.00	1.70	2.55	2.30	1.85	1.20	24	1.95	2.30	2.80	1.95	1.30	.90
9	1.05	1.90	2.60	2.25	1.70	1.20	25	2.10	2.40	2.70	1.90	1.30	.90
10	1.15	2.25	2.70	2.30	1.60	1.10	26	2.15	2.55	2.65	1.85	1.30	.90
11	1.25	2.25	2.65	2.30	1.60	1.00	27	2.25	2.60	2.65	1.85	1.30	.90
12	1.40	2.35	2.80	2.25	1.60	1.00	28	2.20	2.55	2.55	1.80	1.25	.90
13	1.60	2.35	2.90	2.50	1.50	1.00	29	2.15	2.50	2.55	1.70	1.20	.90
14	1.65	2.55	2.95	2.35	1.50	1.00	30	1.90	2.55	2.60	1.60	1.30	.90
15	1.75	2.60	2.90	2.45	1.40	1.00	31	.....	2.55	.....	1.55	1.30	.....
16	1.80	2.70	2.85	2.25	1.50	1.05							

Closed for the winter September 30.

Daily gage height, in feet, of South Boulder and Coal Creek ditch, Colorado, for 1899.

Day.	May.	June.	July.	Aug.	Day.	May.	June.	July.	Aug.	Day.	May.	June.	July.	Aug.
1	.....	1.35	1.50	1.20	12	.....	1.50	1.30	1.00	23	1.10	1.50	1.20	.....
2	.....	1.30	1.50	1.20	13	.....	1.50	1.30	1.00	24	1.10	1.50	1.20	.....
3	.....	1.40	1.50	1.20	14	.....	1.50	1.30	1.00	25	1.10	1.50	1.20	.....
4	.....	1.40	1.50	1.20	15	.....	1.50	(a)	.90	26	1.10	1.50	1.20	.....
5	.....	1.40	1.50	1.20	16	.....	1.50	(a)	.90	27	1.10	1.50	1.20	.....
6	.....	1.50	1.40	1.20	17	.....	1.50	1.30	.80	28	1.10	1.50	1.20	.....
7	.....	1.50	1.40	1.20	18	.....	1.50	1.30	.80	29	1.10	1.50	1.20	.....
8	.....	1.50	1.30	1.00	19	.....	1.50	1.20	.80	30	1.30	1.50	1.20	.....
9	.....	1.50	1.30	1.00	20	.....	1.50	1.20	.....	31	1.30	.....	1.20	.....
10	.....	1.50	1.30	1.00	21	0.90	1.50	1.20	.....					
11	.....	1.50	1.30	1.00	22	.90	1.50	1.20	.....					

a Dry.

Daily gage height, in feet, of Community ditch, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.
1	.....	2.10	2.20	2.20	12	.....	2.20	2.20	2.10	23	1.50	2.20	2.20	.....
2	.....	2.10	2.30	2.20	13	.....	2.20	2.20	2.10	24	1.70	2.20	2.20	.....
3	.....	2.10	2.30	2.20	14	.....	2.20	2.20	2.10	25	1.80	2.20	2.20	.....
4	.....	2.20	2.30	2.20	15	.....	2.20	2.20	.....	26	1.80	2.20	2.20	.....
5	.....	2.20	2.30	2.20	16	.....	2.20	2.20	.....	27	1.90	2.20	2.20	.....
6	.....	2.20	2.20	2.20	17	.....	2.20	2.20	1.25	28	1.90	2.20	2.20	.....
7	.....	2.20	2.20	2.20	18	.....	2.20	2.20	1.30	29	2.10	2.20	2.20	.....
8	.....	2.20	(a)	2.20	19	.....	2.20	2.20	1.20	30	2.10	2.20	2.20	.....
9	.....	2.20	2.20	2.10	20	.....	2.10	2.20	1.20	31	.....	2.20	.....	.....
10	.....	2.20	2.20	2.10	21	.....	2.10	2.20	1.20					
11	.....	2.20	2.20	2.10	22	.....	2.20	2.20	1.20					

a Dry.

BOULDER CREEK AT BOULDER, COLORADO.

The next drainage of importance entering the South Platte from the west is Boulder Creek, an important tributary, furnishing water for a number of irrigation ditches. The station is located about 1½ miles above the town of Boulder, Colorado. The gage rod is inclined and spiked to stakes driven into the ground. The bench mark is the top of a large stone 22 feet west of the gage, and is 5.72 feet above gage datum. Both banks are high and rocky, and not liable to overflow. Two small irrigating ditches take water from the stream above the station, but the amount thus diverted will probably not exceed 5 or 6 second-feet. Results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 171; 1897, Nineteenth Annual Report, Part IV, page 319; 1898, Twentieth Annual Report, Part IV, page 286. The following discharge measurements were made under the direction of A. L. Fellows in 1899:

April 21, gage height, 1 foot; discharge, 84 second-feet.
May 6, gage height, 1.20 feet; discharge, 134 second-feet.
June 15, gage height, 2.50 feet; discharge, 642 second-feet.
August 10, gage height, 1.70 feet; discharge, 276 second-feet.
October 10, gage height, 0.50 foot; discharge, 36 second-feet.

Daily gage height, in feet, of Boulder Creek at Boulder, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	0.32	1.55	2.15	2.90	1.92	1.52	0.48	0.48
2	.30	1.52	2.12	2.92	1.98	1.50	.48	.45
3	.38	1.40	2.12	2.85	2.22	1.45	.48	.48
4	.45	1.38	2.00	2.85	2.45	1.38	.48	.48
5	.35	1.30	1.98	2.78	2.18	1.22	.45	.42
6	.32	1.20	2.05	2.70	2.02	1.12	.48	.40
7	.42	1.22	2.12	2.65	1.88	1.05	.42	.38
8	.42	1.28	2.18	2.58	1.82	.95	.45	.38
9	.48	1.35	2.28	2.48	1.78	.98	.50	.35
10	.55	1.45	2.45	2.50	1.70	.95	.55	.35
11	.92	1.60	2.48	2.42	1.65	.92	.58	.30
12	1.00	1.70	2.62	2.40	1.68	.90	.60	.30
13	1.05	1.90	2.65	2.48	1.62	.88	.65	.35
14	1.10	2.00	2.68	2.45	1.52	.95	.65	.38
15	1.10	2.12	2.62	2.48	1.60	.98	.60	.42
16	1.25	2.15	2.58	2.40	1.65	.92	.58	.42
17	1.20	2.12	2.40	2.30	1.55	.88	.58	.40
18	1.22	2.08	2.75	2.28	1.52	.82	.52	.35
19	1.15	2.12	2.85	2.18	1.45	.78	.55	.30
20	1.10	2.15	2.85	2.12	1.38	.72	.50	.30
21	1.12	2.10	2.90	2.10	1.38	.72	.48	.28
22	1.20	2.08	2.88	2.05	1.32	.62	.50	.28
23	1.25	2.10	2.90	2.02	1.32	.60	.52	.25
24	1.48	2.05	2.85	1.90	1.28	.58	.55	.25
25	1.62	2.08	2.85	1.92	1.20	.58	.60	.22
26	1.68	2.18	2.85	2.00	1.15	.55	.55	.22
27	1.65	2.12	2.78	2.05	1.22	.58	.50	.25
28	1.60	2.12	2.70	2.10	1.45	.55	.48	.22
29	1.55	2.15	2.72	2.20	1.25	.50	.48	.18
30	1.58	2.15	2.82	2.10	1.50	.50	.48	.18
31	.....	2.12	.....	1.90	1.55	.....	.50	.....

ST. VRAIN CREEK AT LYONS, COLORADO.

The gaging station on this drainage is located one-half mile southeast of Lyons, Colorado, below the intersections of the North and South forks of St. Vrain Creek. The gage is inclined and fastened to a post driven into the ground. Both banks are low and liable to overflow. The bed of the stream is composed of gravel. On May 5 a new gage rod was established having the same reading as the old one, and connected with a bench mark 150 feet north of the rod. The elevation of the bench mark is 6.51 feet above gage datum. Supply ditch diverts water above the station, and its discharge should be added to that of the river to obtain the total run-off in the basin. On May 5 at the rating flume, it was discharging, at a gage height of 0.65 foot, 35 second-feet. The observer is Miss Bessie Sites, who reads the gage on the creek, as well as that of the ditch. The results of measurements are found as follows: 1896, Eighteenth Annual Report, Part IV, page 173; 1897, Nineteenth Annual Report, Part IV, page 320; 1898, Twentieth Annual Report, Part IV, page 285. The following discharge measurements were made under the direction of A. L. Fellows in 1899:

April 18, gage height, 3 feet; discharge, 217 second-feet.
May 5, gage height, 2.75 feet; discharge, 137 second-feet.
June 14, gage height, 4.15 feet; discharge, 825 second-feet.
August 9, gage height, 3.20 feet; discharge, 263 second-feet.
October 7, gage height, 2.10 feet; discharge, 37 second-feet.

Daily gage height, in feet, of St. Vrain Creek at Lyons, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	2.05	2.90	3.35	4.40	3.45	2.65	2.05	2.00
2	2.15	2.90	3.55	4.40	3.45	2.65	2.05	2.00
3	2.25	2.70	3.45	4.30	3.60	2.60	2.05	2.00
4	2.25	2.55	3.45	4.30	4.05	2.55	1.95	2.00
5	2.20	2.65	3.45	4.30	4.05	2.55	1.95	2.00
6	2.25	2.90	3.40	4.15	3.85	2.55	1.95	2.00
7	2.30	3.00	3.50	4.00	3.75	2.55	1.95	1.95
8	2.25	2.90	3.50	4.05	3.70	2.65	1.95	1.90
9	2.35	3.00	3.55	4.15	3.65	2.65	2.05	1.90
10	2.70	3.10	3.50	4.05	3.55	2.65	2.05	1.90
11	2.75	3.15	3.75	4.05	3.50	2.65	2.15	1.90
12	2.80	3.35	4.05	3.95	3.40	2.55	2.18	1.95
13	3.00	3.30	4.00	4.00	3.20	2.55	2.15	2.00
14	3.05	3.40	4.25	4.10	3.05	2.55	2.25	2.00
15	3.00	3.40	4.10	4.00	2.95	2.55	2.25	2.00
16	2.90	3.35	4.15	3.90	2.90	2.45	2.25	2.00
17	3.10	3.30	4.30	3.65	2.90	2.45	2.22	2.10
18	3.10	3.30	4.50	3.65	2.95	2.35	2.22	2.05
19	3.20	3.30	4.55	3.65	2.80	2.35	2.15	2.00
20	3.15	3.35	4.65	3.65	2.90	2.25	2.15	2.00
21	3.15	3.25	4.55	3.65	2.90	2.30	2.15	2.00
22	3.20	3.20	4.55	3.65	2.90	2.22	2.15	2.00
23	3.40	3.25	4.30	3.65	2.80	2.25	2.25	2.00
24	3.65	3.25	4.25	3.55	2.80	2.25	2.25	1.95
25	3.65	3.05	4.25	3.60	2.70	2.20	2.25	1.95
26	3.55	3.10	4.30	3.55	2.60	2.18	2.15	1.95
27	3.65	3.40	4.25	3.55	2.60	2.18	2.15	1.90
28	3.45	3.40	4.25	3.60	2.55	2.15	2.05	1.90
29	3.30	3.30	4.35	3.70	2.65	2.12	2.05	1.90
30	3.15	3.40	4.30	3.45	2.65	2.05	2.15	1.90
31	.....	3.30	.....	3.45	2.55	.....	2.15	(a)

a Closed for the winter November 30.

Daily gage height, in feet, of Supply ditch at Lyons, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	0.10	0.90	0.70	1.40	0.90	0.58	0.15	0.10
2	.10	.80	.70	1.40	.90	.52	.15	.10
3	.10	.70	.70	1.40	.85	.55	.15	.10
4	.10	.70	.70	1.40	.80	.50	.15	.10
5	.10	.70	.60	1.40	.80	.52	.10	.10
6	.10	.70	.50	1.30	.80	.37	.10	.10
7	.10	.70	.50	1.30	.80	.20	.10	.10
8	.10	.70	.50	1.30	.80	.40	.10	.10
9	.10	.70	.55	1.30	.80	.40	.10	.10
10	.25	.70	.60	1.30	.80	.20	.10	.10
11	.40	.70	.95	1.30	.80	.20	.20	.10
12	.40	.95	1.20	1.25	.80	.20	.20	.10
13	.40	.80	1.30	1.20	.85	.28	.20	.10
14	.40	.80	1.30	1.20	.70	.22	.15	.10
15	.45	.80	1.40	1.20	.70	.20	.10	.10
16	.50	.80	1.40	1.20	.70	.20	.10	.10
17	.50	.90	1.40	1.20	.70	.20	.10	.10
18	.10	1.00	1.40	1.20	.70	.20	.10	.10
19	.10	1.00	1.40	1.20	.70	.30	.10	.10
20	.10	1.00	1.40	1.20	.70	.20	.10	.10
21	.10	1.00	1.40	1.05	.50	.20	.10	.10
22	.10	1.00	1.40	.90	.50	.20	.10	.10
23	.10	1.00	1.40	.90	.50	.18	.10	.10
24	.10	.70	1.40	.90	.50	.18	.10	.10
25	.10	.40	1.40	.90	.50	.12	.15	.10
26	.10	.60	1.40	.90	.50	.10	.15	.10
27	.10	.80	1.40	.90	.50	.10	.15	.10
28	.10	.80	1.40	.90	.20	.10	.15	.10
29	.10	.75	1.40	.90	.20	.15	.10	.10
30	.50	.70	1.40	.90	.50	.15	.10	.10
31	.....	.70	.....	.90	.60	.....	.10	.....

BIG THOMPSON CREEK AT ARKINS, COLORADO.

This stream drains the country immediately south of the headwaters of Cache la Poudre River, and enters the South Platte 8 miles from Greeley. The location of the station was changed April 1, 1899, from its original position to a point 2 miles above, so that the head of the Home Supply ditch is now below the gaging station, while that of the Handy ditch is still above. It is necessary to include the discharge of this latter canal to give the total run-off of the stream. The present location of the station is at a wagon bridge upon the ranch of Mr. John Chasteen. The gage rod consists of a 2 by 4 inch timber spiked to the downstream side of the bridge on the right-hand side of the river. The bench mark is 25 feet south of the gage and is 9.35 feet above the zero. Handy ditch, which heads one-half mile above the station, was measured twice during the year, the first time, on April 17, at a gage height 0.6 foot, the discharge was 41 second-feet; June 13, at a gage height of 2.30 feet, the discharge was 182 second-feet. The observer is Ed. Chasteen, who records the heights of the canal as well as at the main gaging station. The results of measurements are found as follows: 1896, Eighteenth Annual Report, Part IV, page 175; 1897, Nineteenth Annual Report, Part IV, page 322; 1898, Twentieth Annual Report, Part IV, page 288. The following discharge measurements were made under the direction of A. L. Fellows in 1899:

April 17, gage height, 0.90 foot; discharge, 143 second-feet.
May 4, gage height, 0.97 foot; discharge, 173 second-feet.
June 13, gage height, 2.55 feet; discharge, 941 second-feet.
August 8, gage height, 1.73 feet; discharge, 406 second-feet.
October 6, gage height, 0.50 foot; discharge, 34 second-feet.

Daily gage height, in feet, of Big Thompson Creek at Arkins, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	0.30	1.00	1.90	2.75	1.80	0.90	(a)
2	.40	.95	2.00	2.70	1.80	.90	(a)
3	.35	.90	1.90	2.60	1.80	.85	(a)
4	.45	.90	1.85	2.65	2.15	.80	(a)
5	.45	.90	1.90	2.50	1.90	.90	(a)
6	.50	.90	1.90	2.40	1.80	.85	(a)
7	.55	.90	1.90	2.40	1.75	.80	(a)
8	.35	1.00	2.00	2.30	1.70	.80	0.50
9	.20	1.00	2.10	2.30	1.60	.80	.50
10	.35	1.00	2.15	2.25	1.55	.80	.60
11	.55	1.05	2.25	2.20	1.45	.80	.70
12	.65	1.10	2.30	2.15	1.40	.80	.80
13	.75	1.25	2.45	2.75	1.30	.70	.80
14	.90	1.55	2.60	2.15	1.30	.70	.60
15	.90	1.60	2.65	2.15	1.30	.70	.60
16	.95	1.65	2.75	2.25	1.25	.70	.60
17	.95	1.50	2.80	1.95	1.20	.70	.60
18	.95	1.40	2.80	1.75	1.15	.80	.60
19	1.00	1.40	2.90	2.00	1.20	.70	.60
20	1.10	1.45	3.15	2.00	1.10	.70	.60
21	1.00	1.60	3.15	1.90	1.10	.60	.60
22	1.15	1.40	2.90	2.00	1.05	.60	.60
23	1.20	1.60	2.65	2.00	1.00	.60	.60
24	1.35	1.75	2.50	2.05	1.05	.60	.60
25	1.30	1.85	2.60	1.90	1.00	.65	.60
26	1.45	1.85	2.65	1.85	1.00	.55	.60
27	1.50	2.00	2.55	1.95	.90	.50	.60
28	1.45	2.00	2.70	1.90	.95	.50	.60
29	1.25	1.90	2.80	1.90	.90	.50	.60
30	1.10	1.90	2.75	1.90	.90	.50	.60
31	.....	2.00	.....	1.80	.90	.....	.60

a No readings; closed for the winter October 31.

Daily gage height, in feet, of Handy ditch on Big Thompson Creek, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	0.30	0.95	2.30	0.75	0.30	17	.....	1.10	2.20	1.92	0.70	(a)
2	.....	.30	.95	2.30	.75	.30	18	.....	2.00	2.20	1.55	.70	(a)
3	.....	.30	.72	2.30	.75	.30	19	.....	2.00	2.30	1.55	.70	(a)
4	.....	.55	.60	2.30	1.12	.30	20	.....	1.15	2.30	1.15	.70	(a)
5	.....	.80	.60	2.30	1.55	.30	21	.....	1.15	2.30	.75	.70	.30
6	.....	.78	.70	2.30	1.15	.30	22	.....	.75	2.30	.75	.70	.30
7	.....	.75	.75	2.30	1.55	.30	23	.....	.75	2.30	.75	.70	.30
8	.....	.75	.78	2.30	1.30	.30	24	.....	.75	2.25	.75	.70	.50
9	.....	.75	1.10	2.30	1.02	.30	25	0.30	.75	2.30	.75	.50	.40
10	.....	.75	1.55	2.30	.75	.30	26	.30	.75	2.30	.75	.30	.30
11	.....	.75	2.00	2.30	.70	.30	27	.30	.98	2.30	1.12	.30	.30
12	.....	.75	2.00	1.95	.70	.30	28	.30	.98	2.30	1.50	.30	.30
13	.....	.75	2.10	1.95	.70	.30	29	.30	.98	2.30	1.50	.30	.30
14	.....	2.20	2.20	2.30	.70	.30	30	.30	.75	2.30	1.50	.30	.30
15	.....	2.20	2.20	2.30	.70	.65	31	.....	.75	.....	1.13	.30	.....
16	.....	1.60	2.20	2.30	.70	1.00							

a Dry.

:HE LA POUDRE RIVER AT FORT COLLINS, COLORADO.

ream drains an area of considerable size in northern Colo- headwater tributaries joining those of Laramie on the west. in the description of this latter stream, the Sky-line Canal ater from the Laramie River into Cache la Poudre River, surements of discharge in the latter basin include some of nie waters. The station was established in 1884, at a point miles above Fort Collins, by Prof. L. G. Carpenter, of the State Agricultural College, and the work has been carried his immediate direction. The record is probably the long- among the best of any of the small streams of the West. discharge for 1893 and 1894 will be found in Bulletin No. 30. The following table shows the daily discharge through ting season of the river from 1895 to 1899, inclusive:

arge, in second-feet, of Cache la Poudre River at Fort Collins, Colorado.

1895.

y.	June.	July.	Aug.	Sept.	Day.	May.	June.	July.	Aug.	Sept.
....	1,800	1,690	796	357	17....	1,100	.....	1,030	417	180
....	1,920	1,510	805	339	18....	1,100	.....	996	389	174
....	3,200	1,430	846	300	19....	1,350	.....	950	380	180
....	2,800	1,410	666	283	20....	.....	.....	942	406	188
....	2,500	1,368	612	264	21....	.....	.....	996	398	200
....	2,660	1,240	588	247	22....	.....	.....	1,076	375	216
....	2,750	1,210	565	238	23....	1,300	.....	1,086	404	216
....	2,940	1,100	541	229	24....	1,274	.....	899	415	208
....	3,130	1,035	676	212	25....	1,325	.....	867	381	.....
....	3,450	1,114	652	192	26....	1,404	.....	800	378	.....
....	3,100	1,200	558	196	27....	1,512	1,740	768	312	.....
....	2,500	1,682	512	194	28....	2,060	1,920	722	326	.....
....	.....	1,602	471	192	29....	1,668	1,830	707	343	.....
....	.....	1,352	487	192	30....	1,500	1,715	722	349	.....
380	.....	1,220	480	188	31....	1,400	.....	.....	378	.....
....	.....	1,142	447	184						

1896.

	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
....	.....	531	364	322	17	981	617	320	255
....	.....	538	322	283	18	942	602	192	251
....	.....	512	288	308	19	882	468	320	280
....	.....	487	269	298	20	878	408	294	294
....	.....	468	284	288	21	841	364	283	285
....	.....	456	269	260	22	780	348	422	255
....	.....	432	260	233	23	753	362	517	.....
....	.....	507	238	208	24	753	495	390	.....
....	.....	480	216	268	25	780	453	302	.....
....	.....	409	196	370	26	745	498	269	.....
....	.....	386	173	411	27	707	589	251	.....
....	.....	381	173	361	28	634	468	242	.....
....	.....	381	169	346	29	612	456	266	.....
....	.....	395	166	307	30	559	415	288	.....
....	.....	394	162	278	31	.....	392	358	.....
....	.....	499	158	264					

Daily discharge, in second-feet, of Cache la Poudre River at Fort Collins, Colorado—Continued.

1897.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1		862	3,013	994	466		a 12
2		964	2,378	910	437		
3		978	1,903	1,051		203	
4		1,171	1,681	945			
5		1,189	1,601	792			
6		1,268	1,485	769	a 420		
7		1,425	1,406	797			
8		1,517	1,451	848			
9		1,486	1,961	1,048			
10		1,474	2,191	1,039		186	
11			2,173	971			
12			2,232	837			
13			2,402	797	a 339		
14			2,074	772			
15			2,328	1,028			
16			2,451	907			
17			1,698	828			
18		2,236	1,381	791			
19		2,298	1,449	816			
20		2,857	1,533	738	a 314		
21		3,106	1,548	626			
22		2,654		558			
23		2,987	1,463	520			
24		3,155	1,303	650		142	
25		2,981	1,339	546			
26		2,822	1,468	478			
27	667	2,998	1,278	449	a 248		
28	810	2,461	1,105	441			
29		2,505	1,086	418			
30	704	2,468	1,043	404			
31		2,658		455			

a Average for week.

1898.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1		307	1,148	812	211		a 35
2		271	1,410	792	201		
3		267	1,636	704	180	a 112	
4		243	1,481	645	177		
5		244	1,210	586	186		
6		206	1,035	576	206		
7		219	1,131	554	258		
8		251	1,192	523	220		a 50
9		297	1,267	555	176		
10		337	1,247	592		a 97	
11			1,379	580			
12			1,364	686			
13			1,383	893	a 139		
14			1,612	658			
15			1,411	571			a 66
16			1,605	521			
17			1,658	486		a 60	
18		806	1,629	437			
19		756	1,650	396			
20		755	1,432	332	a 133		
21		664	1,414	319			
22		629		297			a 84
23		702	1,349	288			
24		837	1,358	287		a 43	
25		1,308	1,273	296			
26		1,175	1,109	283			
27	294	1,050	951	267	a 115		
28	308	1,280	905	240			
29		1,130	842	212			
30	316	1,115	824	211			
31		1,265		210			

a Average for week.

iarge, in second-feet, of Cache la Poudre River at Fort Collins, Colorado—Continued.

1899.

Day.	May.	June.	July.	Aug.	Sept.	Oct.
		1,848	2,710	767	358	116
		1,924	2,544	765	351	112
		1,839	2,459	782	365	104
		1,631	2,415	972	335	100
		1,472	2,102	974	324	95
		1,579	2,242	848	302	93
		1,786	2,136	813	290	92
		1,912	1,678	760	280	104
		2,010	1,577	797	263	111
	636	2,168	1,482	735	231	125
	684	2,490	1,303	668	213	
	929	3,103	1,703	629	201	
	1,144	3,619	1,643	592	196	
	1,348	2,831	1,477	555	199	
	1,404	2,702	1,446	504	202	
	1,452	2,822	1,355	682	220	
	1,453	2,981	1,161	533	220	
	1,492	3,040	1,081	469	200	98
	1,663	3,556	974	431	183	128
	1,809	3,865	985	399	162	160
	1,573	3,968	974	381	125	165
	1,380	3,343	972	344	125	110
	1,310	2,945	987	307	125	110
	1,351	2,933	960	301	125	110
	1,521	2,663	947	286	125	
	1,911	2,953	841	286	123	
	2,001	2,943	955	281	141	
	1,936	2,734	928	328	141	
	1,803	2,691	918	322	126	
	2,015	2,606	897	331	120	
	1,881		809	423		

NORTH LOUP RIVER AT ST. PAUL, NEBRASKA.

ream has its source among the sand hills in the western f Cherry County, Nebraska, and drains the country midway he Niobrara River on the north and Middle Loup River on . It has a general southeasterly direction, joining the Mid- at St. Paul to form the main Loup River, which enters ver near Columbus, Nebraska. Calamus River is a tribu- ie North Loup River, entering it near Burwell, Nebraska. surement of its discharge at the bridge 1 mile above the id 2 miles north of Burwell, on May 16, 1899, by Glenn E. owed a discharge of 372 second-feet; North Loup River, on rom a bridge one-fourth of a mile above Burwell, below the Calamus River, was carrying 984 second-feet. The gaging i North Loup River, established in 1895, is located at the ridge 4 miles north of St. Paul. Measurements at this ere not made in 1898, but the station was resumed April 18, n a new rod was located 200 feet downstream from the line nd rail on the wagon bridge. It is a 2 by 3 inch timber, 16 situated on the left bank of the river, at an angle of 30°. h mark is the standard iron pipe, with brass cap, of the tates Geological Survey. It is set with the top 5 inches e ground, and 102 feet northwest of the gage rod, and is at ion of 5.57 feet above gage datum. The zero of the old rod

was 6.54 feet below same bench; so that 0.97 foot should be added to all gage heights after April 18, 1899, to make them comparable with the previous records. The bed of the river is sandy and is liable to change during floods. James Stout, jr., a farmer living about a quarter of a mile from the rod, is the observer. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 176; 1897, Nineteenth Annual Report, Part IV, page 329; 1898, no report. The following discharge measurements were made by Glenn E. Smith during 1899:

Measurements of North Loup River at St. Paul, Nebraska.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec. feet.*	1899.	*Feet.*	*Sec. feet.*
Apr. 18	1.81	1,678	Aug. 8	1.70	1,026
May 5	1.77	1,138	Aug. 23	1.47	920
May 18	1.65	877	Sept. 7	1.70	917
June 7	1.58	1,024	Sept. 19	1.50	796
June 27	3.40	7,690	Sept. 30	1.47	776
July 20	1.35	811			

Daily gage height, in feet, of North Loup River at St. Paul, Nebraska, for 1899.[a]

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1		1.85	1.68	1.95	1.34	1.61	1.52
2		1.85	1.65	1.83	1.37	1.68	1.58
3		1.83	1.66	1.75	1.38	1.73	1.55
4		1.80	1.62	1.68	1.89	1.57	1.55
5		1.80	1.61	1.68	2.20	1.62	1.57
6		1.75	1.60	1.59	2.08	1.70	1.52
7		2.30	1.55	1.55	2.05	1.95	1.50
8		2.32	1.57	1.55	2.01	1.98	1.50
9		2.07	1.56	1.56	1.88	1.85	1.60
10		2.00	1.52	1.57	1.80	1.80	1.63
11		1.95	1.55	1.63	1.92	1.72	1.58
12		1.83	1.53	1.53	1.74	1.68	1.53
13		1.72	1.47	1.49	1.92	1.65	1.57
14		1.72	1.42	1.45	1.86	1.62	1.55
15		1.68	1.41	2.12	1.65	1.60	2.08
16		1.71	1.45	2.27	1.65	1.63	2.03
17		1.73	1.48	2.03	1.57	1.53	1.97
18	1.81	1.70	1.50	1.92	1.48	1.55	1.69
19	1.77	1.64	1.50	1.75	1.55	1.50	1.65
20	1.82	1.68	1.50	1.35	1.57	1.50	1.65
21	1.73	2.30	1.47	1.37	1.62	1.50	1.60
22	1.75	2.08	1.50	1.28	1.58	1.51	1.58
23	1.72	1.93	1.53	1.30	1.57	1.50	1.60
24	1.80	1.90	2.30	1.28	1.54	1.55	1.60
25	1.83	1.87	2.00	1.28	1.54	1.52	1.62
26	1.78	1.85	1.80	1.33	1.55	1.50	1.60
27	3.20	1.78	3.30	1.32	1.57	1.52	1.65
28	2.78	1.75	2.54	1.25	1.53	1.55	1.63
29	2.43	1.77	2.12	1.22	1.54	1.55	1.58
30	1.87	1.73	2.03	1.33	1.57	1.58	1.57
31		1.73		1.35	1.59		1.58

[a] Closed for winter October 31.

MIDDLE LOUP RIVER AT ST. PAUL, NEBRASKA.

This river also has its source in the sand hills of Cherry County, and flows in a general southeasterly direction, joining the North Loup River at St. Paul. Oak Creek is a small stream draining the area east of Loup City and flowing southeasterly into the Middle Loup.

vas measured by Glenn E. Smith, on May 19, 1899, at a point above backwater from the dam, at which time it showed a discharge of econd-feet. The original station was established May 5, 1895, by enn E. Smith, but was discontinued during 1898. It was reestabhed, however, on April 18, 1899, and is located at the highway and lway bridge about 1 mile south of St. Paul. The rod is located the right bank of the stream, 130 feet downstream from the line of nd rail of bridge and consists of an oak rod 2 by 3 inches, 16 feet ıg, set at an angle of 30 degrees. On account of a change in the annel of the river, which threatened to leave the gage rod dry, a cond rod was set on the north side on June 7, 1899. The new rod 2 by 4 inches, hard pine, 12 feet long, set at an angle of 30 degrees, ıd 200 feet downstream from the bridge. The gage datum is the me for both rods. The observer is instructed to read the rod ljacent to the main channel, on whichever side it may be, and the ydrographer is expected to read both rods. The bench mark is the gulation 4-foot iron post of the United States Geological Survey, nd is located 60 feet southeast of the gage rod and 100 feet from the ne of the downstream hand rail of the bridge. It is 7.54 feet above age datum. The zero of the original rod was 7.35 feet below the ame bench mark, so that 0.19 foot should be subtracted from all age heights after April 18, 1899, to make them comparable with the revious records. The observer is A. C. Snyder, a farmer living bout one-half mile from the station. The results of measurements ıay be found as follows: 1896, Eighteenth Annual Report, Part IV, age 181; 1897, Nineteenth Annual Report, Part IV, page 330; 1898, o report. The following measurements were made by Glenn E. mith and Adna Dobson during 1899:

Measurements of Middle Loup River at St. Paul, Nebraska.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec. feet.*	1899.	*Feet.*	*Sec. feet.*
Apr. 18	2.10	988	Aug. 7	2.68	1,612
May 4	1.84	964	Aug. 23	2.20	1,113
May 18	1.70	1,186	Sept. 7	2.25	983
June 7	2.30	920	Sept. 19	2.40	1,112
June 27	4.20	14,631	Sept. 30	2.25	980
July 20	2.18	888			

Daily gage height, in feet, of Middle Loup River at St. Paul, Nebraska, for 1899.[a]

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	1.76	1.59	2.00	2.24	2.29	2.24
2	.....	1.80	1.41	1.87	2.12	2.29	2.29
3	.....	1.79	1.40	1.90	2.16	2.33	2.35
4	.....	1.81	1.62	1.90	3.10	2.19	2.34
5	.....	1.95	1.53	2.12	2.74	2.16	2.37
6	.....	1.82	1.44	2.78	2.70	2.21	2.40
7	.....	1.90	1.54	3.17	2.65	2.18	2.37
8	.....	2.08	1.29	2.71	2.57	2.28	2.34
9	.....	1.93	1.32	2.42	2.66	2.32	2.36
10	.....	1.87	1.25	2.16	2.25	2.34	2.36
11	.....	1.81	1.24	2.12	2.20	2.34	2.34
12	.....	1.78	1.20	2.09	2.18	2.32	2.37
13	.....	1.75	1.33	2.18	2.13	2.28	2.36
14	.....	1.75	1.32	3.10	2.25	2.25	2.40
15	.....	1.60	1.31	2.65	2.39	2.30	2.39
16	.....	1.62	1.32	2.55	2.36	2.30	2.49
17	.....	1.62	1.30	2.36	2.31	2.40	2.47
18	2.10	1.72	1.28	2.20	2.30	2.38	2.49
19	2.09	1.66	1.19	2.12	2.27	2.36	2.42
20	2.12	1.70	1.15	2.12	2.21	2.30	2.40
21	2.09	1.80	1.32	2.09	2.20	2.30	2.41
22	2.10	2.15	1.34	2.11	2.15	2.30	2.42
23	2.00	2.05	1.29	2.12	2.20	2.30	2.41
24	2.00	1.70	1.29	2.15	2.20	2.27	2.40
25	2.03	1.68	2.34	2.06	2.15	2.26	2.45
26	2.00	1.60	4.17	2.02	2.19	2.24	2.42
27	2.12	1.83	3.51	2.06	2.16	2.27	2.45
28	2.39	1.92	3.30	2.30	2.12	2.26	2.44
29	2.00	1.66	2.84	2.20	2.10	2.24	2.47
30	1.74	1.49	2.35	2.10	2.13	2.22	2.49
31	.....	1.84	.....	2.42	2.21	.....	2.49

[a] Closed for winter October 31.

LOUP RIVER AT COLUMBUS, NEBRASKA.

This river is formed by the junction of the North Loup and Middle Loup rivers at St. Paul, Nebraska, and 60 miles below St. Paul enters the Platte River near Columbus, Nebraska. Cedar River is a tributary of Loup River, and flows southeasterly, emptying into Loup River at Fullerton, 30 miles below St. Paul. At Ericson, Nebraska, a large dam has been built for the purpose of turning Cedar Creek into a canal to be used for irrigation. The dam backs the water for about one-half a mile, forming a pond 1,000 feet in width in some places. May 17, 1899, Glenn E. Smith measured the river 500 feet below the above dam, and below the race of a small mill near by, and found a discharge of 113 second-feet; at the same time the mill race was carrying 10 second-feet, and the Cedar Valley irrigation canal 20 second-feet—this latter being measured about 1,000 feet below the head gates. On the same day a measurement was made by wading, at a point 2 miles from Ericson and above the backwater from the dam, and gave a discharge in Cedar River of 107 second-feet. A tributary known as Dry Cedar enters near this point—there being seldom any discharge from it except during the rainy season. Near the mouth of this tributary are several small springs, not large enough, however, to give a continuous discharge. They were found to be flowing on May 17, at a point about 1 mile north of Ericson, 5 second-feet, while 5 miles above the channel was dry. The gaging station

›up River is located near the iron bridge of the Union Pacific just west of Columbus, Nebraska, and only a short distance › mouth of the river. The gage rod is 150 feet from the nd is of oak, fastened to a pile which forms part of the train- s above the bridge. The bench mark is the regulation 4-foot of the United States Geological Survey, placed 72 feet east l, and is 13.27 feet above gage datum. The results of meas- › may be found as follows: 1896, Eighteenth Annual Report, page 182; 1897, Nineteenth Annual Report, Part IV, page ›, Twentieth Annual Report, Part IV, page 294. The fol- ıeasurements of discharge were made by Glenn E. Smith 899:

Measurements of Loup River at Columbus, Nebraska.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899—Continued.	*Feet.*	*Sec.-feet.*
.....	Frozen.	2,726	July 9	5.40	3,435
.....	4.95	3,004	July 23	4.25	1,792
.....	5.00	2,699	Aug. 6	4.93	3,251
.....	5.05	3,057	Aug. 20	4.61	2,267
.....	5.54	4,073	Sept. 3	4.40	1,902
.....	4.86	2,628	Sept. 17	4.40	1,840
.....	4.75	1,921	Oct. 5	4.60	2,402
.....	5.80	7,728	Oct. 15	4.80	1,983

›age height, in feet, of Loup River at Columbus, Nebraska, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
.....	.....	5.30	.....	5.50	4.30	4.80	4.40
.....	5.40	4.95	5.00	.....	4.25	4.85	4.40
.....	5.60	4.60	.....	5.90	4.20	4.80	4.40
.....	5.80	4.70	4.80	.....	4.25	4.80	4.40
.....	5.70	4.90	.....	5.70	4.55	4.70	4.45
.....	5.00	4.95	5.40	.....	4.93	4.60	4.40
.....	4.90	5.05	.....	5.60	4.90	4.55	4.40
.....	5.00	4.95	.....	.....	4.80	4.50	4.40
.....	4.95	5.15	.....	.....	4.85	4.80	4.40
.....	4.90	5.00	.....	4.40	4.80	4.70	4.40
.....	5.00	4.95	5.40	.....	4.70	4.60	4.40
.....	4.90	4.80	.....	4.00	4.85	4.50	4.40
.....	4.80	4.85	.....	4.20	4.20	4.45	4.40
.....	4.90	4.97	.....	4.21	4.10	4.40	4.50
.....	5.10	5.30	.....	4.20	4.50	4.40	4.80
.....	5.20	5.15	4.80	4.10	4.20	4.40	4.70
.....	5.15	5.14	.....	4.20	4.40	4.40	4.75
.....	5.10	4.95	4.70	4.15	4.40	4.40	4.70
.....	5.00	5.00	.....	4.00	4.50	4.40	4.60
.....	4.90	5.05	.....	3.98	4.61	4.40	4.50
.....	4.90	5.40	4.95	4.00	4.80	4.40	4.50
.....	4.90	5.80	.....	4.10	4.70	4.40	4.70
.....	5.00	5.54	.....	4.25	4.75	4.40	4.60
.....	4.90	5.40	5.10	4.20	4.80	4.40	4.60
.....	4.85	.....	.....	4.21	4.81	4.40	4.55
.....	4.90	.....	.....	4.20	4.80	4.40	4.55
.....	5.00	.....	5.90	4.20	4.81	4.40	4.50
.....	5.40	.....	.....	4.22	4.80	4.40	4.55
.....	5.60	5.40	5.80	4.23	4.70	4.40	4.60
.....	5.80	.....	.....	4.50	4.60	4.40	4.65
.....	.....	.....	.....	4.40	4.70	.....	4.65

PLATTE RIVER AT COLUMBUS, NEBRASKA.

Lower Platte River is a sandy stream, the bed shifting during the high stages, through which considerable water is lost during the summer season. On September 8 there were only 20 second-feet flowing in the middle channel at the bridge of the Burlington and Missouri Railroad near Central City, Nebraska, this point being 20 miles below Grand Island and 40 miles above Columbus. On September 19, Glenn E. Smith reports that the stream was dry at this point. Mr. Adna Dobson reports the river dry at Grand Island on September 30. The gaging station at Columbus was established in 1895, and is located on the left bank of the main channel of the river, 75 feet above the Meridian bridge south of Columbus. It is about 4 miles above the mouth of the Loup River. The gage consists of an inclined oak timber fastened to cross-ties which are bedded in the bank of the river. The channel is straight both above and below the gage. The bench mark is a standard 4-foot iron post of the United States Geological Survey, and is located 44.5 feet east of the gage, 60 feet north of the north end of the north bridge truss, and 10 feet west of a cottonwood tree 6 inches in diameter. Its elevation is 7.06 feet above gage datum. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 190; 1897, Nineteenth Annual Report, Part IV, page 334; 1898, Twentieth Annual Report, Part IV, page 295. The following discharge measurements were made by Glenn E. Smith and Adna Dobson during 1899:

Measurements of Platte River at Columbus, Nebraska.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec. feet.*
Jan. 22		Dry.	July 9	4.61	17,032
Feb. 19		55	July 23	3.84	8,698
Apr. 9	3.50	6,736	Aug. 6	4.00	9,450
Apr. 23	3.94	8,210	Aug. 20	2.80	4,338
May 7	4.14	10,121	Sept. 3	.90	93
May 23	3.81	7,878	Sept. 17		15
June 4	4.01	9,294	Oct. 5		Dry.
June 18	4.00	9,279	Oct. 15		8
June 29	4.82	18,631			

height, in feet, of Platte River at Columbus, Nebraska, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.
.....	.....	3.90	4.30	5.10	3.70	1.20
.....	.00	3.73	4.10	4.90	3.65	1.10
.....	.00	3.80	4.00	4.80	3.60	.90
.....	4.00	3.85	4.01	4.85	3.68	.85
.....	4.80	3.93	3.40	4.95	3.88	.80
.....	4.50	4.00	3.70	4.98	4.00	.70
.....	4.40	4.14	4.00	4.97	3.90	.65
.....	3.70	3.96	3.81	4.98	3.96	.60
.....	3.45	4.00	3.65	4.61	3.94	.50
.....	3.50	3.94	3.64	4.63	3.90	.....
.....	3.55	3.87	4.50	4.62	3.80	.....
.....	3.60	3.80	4.60	4.60	4.00	.....
.....	3.65	3.73	4.80	4.58	3.50	.....
.....	3.20	3.68	4.95	4.56	3.40	.....
.....	3.10	3.60	4.98	4.50	3.30	.....
.....	3.00	3.63	4.99	4.50	2.90	.....
.....	3.10	3.41	4.98	4.40	2.95	.....
.....	3.20	3.36	4.00	4.23	2.85	.....
.....	3.60	3.21	4.00	4.11	2.81	.....
.....	3.80	3.30	4.00	4.10	2.80	.....
.....	4.00	3.91	4.20	4.00	2.81	.....
.....	3.90	4.10	4.40	3.90	2.80	.....
.....	3.94	3.81	4.50	3.83	2.75	.....
.....	3.50	4.50	4.63	3.80	2.70	.....
.....	3.93	4.70	4.40	3.70	2.10	.....
.....	4.50	4.90	4.43	3.72	2.55	.....
.....	3.90	5.05	4.50	3.74	2.40	.....
.....	3.83	4.83	4.75	3.80	2.00	.....
.....	3.90	4.70	4.85	3.90	1.60	.....
.....	3.93	4.60	5.15	3.92	1.50	.....
.....	.....	4.51	.....	3.85	1.35	.....

e washed out; gage heights estimated. September 10–October 28, sand bar; no d for the winter September 9.

ELKHORN RIVER AT NORFOLK, NEBRASKA.

r rises in the sand hills in Rock County, Nebraska, and eneral southeasterly direction, entering the Platte River les above its mouth. Two gaging stations are maintained r, one at Norfolk, Nebraska, and the other at Arlington, The station at the former place is at the Thirteenth street iles south of Norfolk and above the mouth of the North horn River. The gage consists of an inclined oak timber cross-ties, which are firmly bedded in the bank of the bench mark is a standard 4-foot iron pipe of the United ›gical Survey, 35 feet west and 7 feet north of the top of 5 feet west of an ash tree. Its elevation is 10.70 feet above . The bed of the river is composed of sand and mud. A measurements of the North Fork were made and are . The results of measurements may be found as follows: enth Annual Report, Part IV, page 191; 1897, Nineteenth ›ort, Part IV, page 335; 1898, Twentieth Annual Report, ge 296. The following measurements were made by Glenn ıring 1899:

r:

6, gage height, frozen; discharge, 272 second-feet.
gage height, 1.94; discharge, 505 second-feet.
age height, 2.01 feet; discharge, 572 second-feet.

Elkhorn River—Continued.

May 25, gage height, 2.72 feet; discharge, 830 second-feet.
July 7, gage height, 1.70 feet; discharge, 427 second-feet.
August 17, gage height, 1.30 feet; discharge, 274 second-feet.
September 25, gage height, 1.12 feet; discharge, 184 second-feet.

North Fork of Elkhorn River:

February 20, discharge, 119 second-feet.
April 27, discharge, 122 second-feet.
May 25, discharge, 414 second-feet.
August 17, discharge, 81 second-feet.
September 25, discharge, 85 second-feet.

Daily gage height, in feet, of Elkhorn River at Norfolk, Nebraska, for

Day.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	1.94	2.07	2.45	1.20	0.97
2	.....	2.24	2.03	2.20	1.23	.97
3	.....	2.30	1.93	1.97	1.27	.76
4	.....	3.20	1.85	1.66	1.32	.70
5	.....	2.41	1.85	1.76	1.33	.67
6	.....	2.31	1.87	1.74	1.33	1.06
7	1.90	2.24	2.45	1.68	1.36	1.08
8	1.87	2.16	2.22	1.71	1.35	1.12
9	1.90	2.06	1.92	1.67	1.45	1.15
10	1.93	2.00	1.82	1.73	1.27	1.13
11	2.00	1.92	1.75	1.73	1.28	1.13
12	2.01	1.83	1.74	1.78	1.48	1.10
13	2.05	1.78	1.64	1.69	1.48	1.06
14	2.05	1.73	1.63	1.65	1.33	1.02
15	2.03	1.77	1.64	1.56	1.34	1.06
16	1.98	1.77	1.65	1.51	1.33	1.11
17	1.98	1.74	1.60	1.48	1.38	1.09
18	1.97	1.70	1.53	1.45	1.26	1.11
19	1.99	1.80	1.57	1.43	1.25	1.04
20	1.90	3.50	1.57	1.45	1.23	1.03
21	1.97	3.58	1.57	1.38	1.25	1.02
22	1.89	3.34	1.53	1.34	1.23	1.03
23	1.85	2.63	1.45	1.26	1.17	1.04
24	1.84	2.65	1.55	1.21	1.17	1.17
25	1.84	2.75	2.07	1.23	1.14	1.11
26	1.87	2.80	1.75	1.23	1.13	1.10
27	1.93	2.85	2.65	1.24	1.12	1.12
28	1.95	2.75	3.75	1.24	.97	1.12
29	1.89	2.35	3.40	1.24	.95	1.13
30	1.73	2.20	3.02	1.21	.99	1.12
31	.....	2.07	.....	1.22	.97	.....

Closed for winter October 31.

ELKHORN RIVER AT ARLINGTON, NEBRASKA.

The station at Arlington, Nebraska, was established by Gl Smith April 28, 1899, and is located at the wagon bridge 1 mile the town of Arlington. The original rod was fastened to cro which are solidly bedded in the river bank. It consisted of a n stake 3 by 4 inches and 12 feet long. It was placed 200 feet down from the bridge on the west bank of the river. Bench mark 1 a large spike driven in a pile 50 feet upstream from the rod, 6.36 feet above gage datum. Bench mark No. 2 is a large spike in a piling 20 feet back and 10 feet upstream from the rod, and feet above gage datum. Bench mark No. 3 is a vertical spike into a small leaning tree 5 feet downstream from the rod, and *feet above* gage datum. On May 10 the rod was washed out; (

s replaced by an oak rod 2 by 6 inches and 16 feet long. This placed on the same bank as the first rod, but was set 25 feet upstream. The gage datum was not changed. S. P. Ham- farmer living about 300 yards from the gage rod, is the r. The following discharge measurements were made by . Smith during 1899:

Measurements of Elkhorn River at Arlington, Nebraska.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
		337	July 8	2.23	1,016
		269	Aug. 9	1.72	732
	1.78	794	Aug. 18	1.40	606
	3.90	1,779	Sept. 15	.82	344
		1,626	Sept. 24	.75	340
	4.24	2,462	Oct. 13	.90	351
	2.70	1,199			

age height, in feet, of Elkhorn River at Arlington, Nebraska, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
		1.84	3.81	2.68	1.32	0.87	0.68
		2.07	3.65	2.68	1.25	.89	.69
		1.86	3.63	3.19	1.17	.76	.68
		1.96	3.50	2.97	1.36	.73	.67
		2.30	3.41	2.81	1.50	.70	.68
		3.00	3.42	2.66	1.40	.72	.73
		4.37	3.54	2.38	1.56	.74	.74
		3.96	2.87	2.23	2.00	.75	.78
		3.91	2.58	2.23	1.70	.74	.79
		(a)	2.38	2.12	1.57	.79	.82
		(a)	2.35	2.13	1.66	.80	.86
		(a)	2.40	2.02	1.40	.82	.88
		(a)	5.35	2.10	1.41	.81	.90
		(a)	4.94	1.94	1.35	.84	.92
		(a)	4.55	1.86	1.42	.79	.93
		(a)	4.12	1.83	1.49	.75	.94
		(a)	4.30	1.76	1.48	.74	.92
		(a)	4.48	1.68	1.39	.73	.91
		(a)	3.67	1.64	1.27	.73	.92
		(a)	3.16	1.63	1.24	.65	.96
		(a)	2.67	1.57	1.09	.66	.98
		(a)	2.76	1.50	1.10	.69	1.02
		(a)	2.75	1.55	1.09	.72	1.04
		(a)	2.65	1.36	1.21	.75	1.10
		(a)	2.51	1.30	1.23	.76	1.12
		(a)	2.21	1.27	1.03	.70	1.11
		(a)	2.32	1.27	1.02	.69	1.12
	1.78	(a)	2.19	1.25	1.07	.66	1.13
	1.76	4.24	2.32	1.26	1.03	.64	1.12
	1.81	4.15	2.64	1.20	1.01	.65	1.13
		4.17		1.22	.85		1.11

Closed for winter October 31. a Rod washed out.

REPUBLICAN RIVER AT SUPERIOR, NEBRASKA.

river rises in the northeastern part of Colorado, and after g Nebraska it flows in a general easterly direction along the n boundary of the State to 98° west longitude, where it bends nsas, and thence flows southeasterly until it joins the Smoky ver at Junction to form the Kansas River. All of the tribu- f the Kansas River have their sources in the Great Plains

region, none drawing their supply from a mountain area. They are also different from ordinary streams, in that the rainfall is less at the headwaters, gradually increasing downstream. Two gaging stations are maintained on Republican River, one at Superior, Nebraska, just before it enters Kansas, and the other at Junction, Kansas. The former station was established June 20, 1896, about one mile west from Superior, Nebraska. The old gage rod was first placed just above the river highway bridge, which is itself 75 yards above the dam which diverts water into the mill race. In the spring of 1898 two other gages were located and have been exclusively used during the last season. The first gage was placed in the river a few feet upstream from the crest of the dam the zero being at same elevation as the crest, the second is in the mill race, where it is crossed by a wagon bridge about 50 yards below its head. Discharge measurements of the river are made from the highway bridge, thus determining at once the discharge through the mill race and from the dam. The discharge from the mill race was measured in order that it might be deducted from the total discharge of the river to give the amount passing over the dam. The bench mark for the river gage is a standard 4-foot iron post of the United States Geological Survey, and is situated 83 feet north of the upstream cylinder of the north pier of the bridge, and 1 foot inside of a wire fence. Its elevation is 4.92 feet above datum of gage at dam. The gage of the mill race reads 2 feet higher than that of the river gage, so that its zero is 6.92 feet below the same bench mark. During 1899 Glenn E. Smith made an examination of a portion of the upper Republican River. On September 6, at Oxford, Nebraska, the river channel was dry and was reported to have been in this condition for ten days. At Orleans, about 12 miles below, there was an estimated discharge of 0.3 second-feet—this small amount coming from Sappa River, which enters at this point. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 201; 1897, Nineteenth Annual Report, Part IV, page 339; 1898, Twentieth Annual Report, Part IV, page 317. The following discharge measurements were made by Glenn E. Smith during 1899:

Measurements of Republican River at Superior, Nebraska.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Foot.*	*Sec.-feet.*	1899.	*Foot.*	*Sec.-feet.*
January 24	Frozen.	463	June 26	0.42	204
February 14	Frozen.	131	July 6	90	732
April 10	0.98	738	July 26	23	135
May 1	.75	382	August 11	40	215
May 13	.61	442	September 6		0
June 2	.51	291	September 29		0
June 16	.63	439	October 17		0

Measurements of mill race at Superior, Nebraska.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
April 10	2.98	49	July 6	2.80	56
May 1	3.00	0	August 11	2.70	56
May 13	3.10	47	September 6	2.60	50
June 2	2.60	55	September 29	1.20	25
June 16	3.50	53	October 17	1.50	50
June 26	3.40	59			

No water was passing over the dam, and all was in the mill race on September 6 and 29 and October 17. The figures which are noted as gage heights in the mill race during 1899 are, in fact, measurements of the center depth at the gaging section. As expected, this has proved to be a better basis for the computation of areas of cross section there than the gage height observed in previous years.

Daily gage height, in feet, of Republican River at Superior, Nebraska, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1		0.97	0.74	0.45	1.05	0.91	0.12	(a)
2		1.00	.70	.51	.90	.95	.09	(a)
3		.95	.73	.60	.80	.82	.20	(a)
4		.94	1.18	.60	.80	.68	(a)	(a)
5		1.00	.68	.47	.79	.60	(a)	(a)
6		.98	.64	.45	.90	.45	(a)	(a)
7		1.04	.50	.47	.93	.52	(a)	(a)
8		.97	.61	.45	.89	.42	(a)	(a)
9		1.00	.68	.40	.63	.41	(a)	(a)
10		.97	.63	.40	.51	.41	(a)	(a)
11		.94	.63	.41	.45	.40	(a)	(a)
12		.89	.60	.35	.42	.41	(a)	(a)
13		.90	.61	.33	.52	.50	(a)	(a)
14		.90	.67	.70	.47	.60	(a)	(a)
15		.88	.63	.53	.42	.44	(a)	(a)
16		.74	.69	.63	.45	.39	(a)	(a)
17		.83	.65	.42	.45	.62	(a)	(a)
18		.83	.64	.41	.46	.52	(a)	(a)
19	1.13	.82	.65	.12	.30	.42	(a)	(a)
20	.94	.77	.93	.35	.40	.41	(a)	(a)
21	.89	.82	1.50	.35	.49	.27	1.25	(a)
22	.99	.73	1.02	.32	.42	.35	(a)	(a)
23	.99	.63	.80	.60	.35	.31	(a)	(a)
24	.96	.75	.74	.63	.20	.20	(a)	(a)
25	.92	.70	.70	.30	.28	.30	(a)	(a)
26	.94	.73	.80	.42	.26	.45	(a)	(a)
27	.93	.75	.73	2.60	.25	.72	(a)	(a)
28	.95	.75	.66	2.05	.26	.33	(a)	(a)
29	.92	.79	.65	1.31	1.22	.21	(a)	(a)
30	.91	.70	.63	1.22	.69	.33	(a)	(a)
31	.96		.54		.45	.20		(a)

a September 4 to 20, 22 to 30, no water flowing over dam. Closed for winter October 31.

Daily gage height, in feet, of mill race at Superior, Nebraska, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	2.98	2.84	2.54	2.15	3.05	2.86	1.15
2	.....	3.08	2.90	2.06	1.80	2.85	2.12	1.53
3	.....	3.03	2.93	2.65	2.18	2.38	2.79	1.10
4	.....	2.98	3.42	2.67	2.30	1.94	2.19	1.60
5	.....	3.02	2.61	2.50	2.34	1.86	2.00	1.20
6	.....	2.97	2.61	2.49	2.40	2.05	2.06	1.15
7	.....	3.04	2.15	2.59	2.42	2.87	1.41	1.28
8	.....	2.98	3.00	2.48	2.54	2.64	1.63	1.87
9	.....	3.04	3.10	2.41	2.01	2.78	1.50	2.79
10	.....	2.99	3.04	2.46	2.22	2.80	1.84	1.45
11	.....	2.92	3.01	2.69	2.38	2.07	3.62	2.15
12	.....	2.89	3.06	3.20	2.25	2.70	3.44	1.12
13	.....	2.90	3.10	3.22	2.94	2.90	2.88	1.70
14	.....	2.89	3.25	3.52	2.84	3.00	3.54	1.30
15	.....	2.77	3.19	3.35	2.80	2.78	3.88	1.78
16	.....	2.47	3.20	3.50	2.86	2.76	3.74	3.40
17	.....	2.97	3.12	3.38	3.08	2.95	3.79	2.30
18	.....	2.84	3.15	3.27	3.26	2.78	3.65	3.10
19	3.13	2.82	3.36	2.56	2.95	2.68	3.53	2.74
20	2.88	2.77	3.95	3.20	2.90	2.75	3.56	2.27
21	2.84	2.83	4.38	3.21	3.03	2.35	3.94	2.75
22	2.94	2.73	3.15	2.95	3.04	2.60	3.70	1.72
23	2.93	2.51	2.97	3.35	2.93	2.48	3.50	3.01
24	2.90	2.70	2.77	3.52	2.81	2.56	3.80	1.86
25	2.81	2.75	2.73	2.43	2.00	2.60	3.43	4.02
26	2.94	2.78	2.82	3.12	2.80	2.66	3.81	3.78
27	2.90	2.83	2.78	5.69	2.70	3.00	2.17	3.63
28	2.90	2.85	2.66	4.51	2.71	3.20	2.83	3.43
29	2.95	2.80	2.83	2.45	3.80	3.10	1.20	3.92
30	2.95	2.75	2.83	2.45	2.93	2.86	1.10	3.82
31	2.96	.....	2.73	.....	3.43	2.90	.....	3.33

REPUBLICAN RIVER AT JUNCTION, KANSAS.

The gaging station at this point, established by Arthur P. Davis April 26, 1895, is located at the wagon bridge at the north end of Washington street just above the mouth of the river. The gage consists of two oak timbers bolted to a post and to a cottonwood tree. One bench mark consists of a 60-penny spike driven into the base of the abutment of the bridge at an elevation of 10.67 feet on the rod; the second bench mark is the top of a stone in the base of the bridge abutment 18 feet south of the gage and at an elevation of 14.51 feet above gage datum. The right bank is high, but the left is low and may overflow in high water. The bed of the stream is sandy and liable to change. Results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 205; 1897, Nineteenth Annual Report, Part IV, page 339; 1898, Twentieth Annual Report, Part IV, page 318. The following discharge measurements were made by W. G. Russell in 1899:

April 19, gage height, 3.90 feet; discharge, 737 second-feet.
May 26, gage height, 4.20 feet; discharge, 1,029 second-feet.
June 7, gage height, 4.40 feet; discharge, 1,224 second-feet.
June 15, gage height, 3.80 feet; discharge, 936 second-feet.
October 19, gage height, 2.55 feet; discharge, 85 second-feet.

Daily gage height, in feet, of Republican River at Junction, Kansas, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.40	4.15	4.00	4.20	3.65	3.70	5.90	4.10	3.10	2.65	2.65	2.80
2	3.45	4.15	4.15	4.20	3.90	4.25	5.90	4.55	3.05	2.70	2.85	2.90
3	3.75	4.20	4.35	4.20	4.25	6.95	5.20	5.45	3.00	2.75	2.90	3.20
4	4.00	4.05	4.50	4.15	4.10	10.00	5.70	4.85	3.10	2.60	2.95	3.50
5	3.95	3.75	4.80	4.15	3.85	7.25	6.05	4.70	2.85	2.60	2.80	3.00
6	3.95	3.70	4.85	4.20	3.70	5.20	4.90	4.40	2.80	2.85	2.60	3.80
7	3.80	3.60	4.85	4.15	3.65	4.60	6.00	4.25	2.85	3.25	2.60	3.80
8	3.65	3.65	4.80	4.20	3.90	6.10	6.20	4.00	2.90	2.80	2.70	3.20
9	3.50	3.50	4.70	4.20	5.45	8.80	5.90	3.80	2.90	2.75	2.80	3.00
10	3.65	3.50	4.65	4.20	5.35	7.25	5.60	3.65	2.80	2.70	2.80	3.20
11	3.85	3.50	4.80	4.20	4.10	5.40	5.00	3.55	2.70	2.55	2.50	3.30
12	3.90	3.50	4.90	4.15	4.05	4.40	4.90	3.60	2.65	2.55	2.50	3.50
13	3.95	3.55	5.15	4.10	3.80	4.25	4.40	4.50	2.65	2.70	2.60	3.20
14	3.90	3.60	4.90	4.00	3.75	4.00	4.10	4.45	2.70	2.70	2.40	3.50
15	3.85	3.65	5.25	4.05	3.60	3.80	4.15	4.20	2.60	2.65	2.60	3.20
16	3.70	3.70	5.20	4.00	3.60	3.65	3.90	3.80	2.70	2.50	2.40	3.30
17	3.60	4.05	5.40	4.00	3.60	3.60	3.70	4.05	2.70	2.50	2.60	3.30
18	3.40	3.90	5.35	4.00	3.50	3.50	3.70	3.80	2.55	2.60	2.80	3.20
19	3.50	3.90	4.90	3.90	3.40	3.75	3.85	3.60	2.60	2.55	3.20	3.20
20	3.70	3.95	4.90	3.95	4.35	3.60	3.70	3.40	2.70	2.50	2.80	3.10
21	3.85	4.00	4.85	3.80	6.00	3.55	3.60	3.40	2.70	2.60	2.70	3.40
22	3.85	3.95	4.50	3.80	6.40	3.35	3.55	3.30	2.65	3.25	2.60	3.60
23	3.70	4.05	4.50	3.80	6.15	4.35	3.50	3.35	2.65	3.10	2.80	3.50
24	3.65	4.15	4.10	3.80	4.70	4.30	3.55	3.40	2.60	3.35	2.90	3.50
25	3.65	3.90	4.10	3.80	4.55	4.75	3.30	3.30	2.70	4.20	2.90	3.60
26	3.70	3.85	4.20	3.75	4.20	4.15	3.30	3.00	2.60	4.05	2.70	3.40
27	3.70	4.05	4.15	3.60	8.20	4.10	3.20	3.55	2.65	4.35	2.60	3.40
28	3.75	3.95	4.10	3.70	6.15	4.10	3.20	3.10	2.80	4.05	2.70	3.60
29	3.80	.....	4.10	3.70	4.55	4.80	3.20	3.10	2.90	3.55	2.90	3.90
30	3.85	.....	4.20	3.75	4.00	6.70	3.25	3.25	2.65	3.20	2.90	3.80
31	4.00	.....	4.20	.....	3.95	.....	3.35	3.05	.....	2.20	.....	3.40

SOLOMON RIVER AT NILES, KANSAS.

This river, one of the principal tributaries of Smoky Hill River, es in western Kansas, and flows in a general easterly direction. ering the Smoky Hill River near Solomon, Kansas. The station Niles was established May 5, 1897, and is located at a bridge one-f mile west of the town and 7 miles above the mouth of the river. e rod of the wire gage is spiked to the floor of the bridge. The ıch mark is the upper of three nails driven into a cottonwood tree inches in diameter, on the north side of the river and 25 feet east the bridge, at an elevation of 24.96 feet above gage datum. The ınnel is straight for about 100 feet above and below the section. e current is sluggish; the right bank is high, and the left bank ırflows only at very high stages. The bed of the stream is muddy. e discharge measurements may be found as follows: 1897, Nineteenth nual Report, Part IV, page 342; 1898, Twentieth Annual Report, rt IV, page 214. The following discharge measurements were de by W. G. Russell during 1899:

April 20, gage height, 4.90 feet; discharge, 120 second-feet.
May 27, gage height, 5.10 feet; discharge, 129 second-feet.
May 29, gage height, 11.65 feet; discharge, 1,529 second-feet.
June 16, gage height, 13.60 feet; discharge, 2,270 second-feet.

Daily gage height, in feet, of Solomon River at Niles, Kansas, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	5.70	5.35	5.20	4.75	5.30	18.75	6.40	5.10	4.40	5.00	4.40
2	5.30	5.65	5.30	5.25	4.65	5.10	11.85	10.75	5.00	5.10	4.80	4.90
3	.....	5.65	5.30	5.30	5.75	8.35	8.90	10.00	5.10	4.70	4.70	4.60
4	5.20	5.65	5.30	5.25	5.35	20.00	9.65	8.25	5.10	4.45	4.80	4.40
5	5.20	5.70	5.25	5.25	4.90	23.60	8.90	6.80	4.95	4.30	4.90	4.40
6	.....	5.65	5.40	5.25	4.90	16.70	8.30	6.20	4.85	4.40	5.00	4.90
7	5.10	5.65	5.25	5.25	4.85	8.30	9.70	5.80	5.05	4.45	.....	4.70
8	5.30	5.65	5.45	5.35	5.10	16.80	8.60	5.65	4.95	4.45	4.30	4.60
9	.....	5.55	5.65	5.20	6.00	21.50	7.45	5.55	4.90	4.30	4.80	4.70
10	5.20	5.60	5.45	5.25	5.65	21.35	6.85	5.30	4.85	4.40	4.60	4.70
11	.....	5.65	5.55	5.20	6.35	15.60	6.75	5.35	4.85	4.60	4.20	4.90
12	5.20	5.45	5.45	5.30	6.55	10.00	6.60	5.30	4.70	4.40	4.80	4.70
13	.....	5.45	5.15	5.15	6.00	8.75	7.25	5.40	4.60	4.20	4.40	4.90
14	.....	5.45	5.95	5.10	5.65	7.65	10.60	5.25	4.50	4.35	4.40	4.80
15	5.30	5.50	6.50	5.00	5.15	9.80	7.65	5.25	4.60	4.35	4.50	5.00
16	.....	5.55	6.25	5.15	5.00	13.25	6.40	5.35	4.50	4.35	5.00	5.10
17	5.20	5.40	6.25	5.05	5.05	10.10	6.15	6.15	4.50	4.15	4.50	5.00
18	.....	5.45	5.95	4.95	5.00	7.15	6.40	6.55	4.50	4.15	4.40	4.90
19	6.40	5.35	5.70	5.00	4.80	6.55	6.80	6.30	4.45	4.15	4.30	5.10
20	.....	5.45	5.55	5.05	5.00	6.35	6.40	6.30	4.40	4.10	4.50	5.00
21	.....	5.40	5.50	4.85	5.10	6.15	6.40	5.90	4.45	4.20	4.40	5.10
22	6.10	5.45	5.55	4.85	5.45	5.85	6.05	5.60	4.70	4.30	4.90	4.90
23	5.75	5.35	5.25	4.90	5.30	7.15	5.85	5.50	4.55	4.30	4.50	5.00
24	5.50	5.25	5.25	4.95	5.35	8.15	5.65	5.20	4.45	4.20	4.50	4.70
25	5.25	5.40	5.35	4.80	5.20	12.45	5.65	5.15	4.45	4.55	4.70	4.80
26	5.65	5.35	5.25	4.90	5.10	12.90	5.70	5.20	4.40	4.60	4.50	4.90
27	5.50	5.45	5.15	4.85	8.50	11.85	5.40	5.10	4.55	10.25	4.70	4.70
28	5.70	5.30	5.25	4.80	14.45	11.50	5.35	5.10	4.40	8.15	4.60	4.60
29	5.75	.....	5.30	4.70	11.95	14.60	5.40	5.05	4.30	6.15	4.80	4.70
30	5.65	.....	5.25	4.80	7.15	18.60	5.55	4.85	4.45	5.30	4.70	4.60
31	5.60	.....	5.05	.....	5.80	.....	5.25	4.90	.....	5.00	.....	4.70

SALINE RIVER AT SALINA, KANSAS.

This river and the Solomon are the two principal tributaries of Smoky Hill River. They are of a similar type to the other tributaries of Kansas River, as they are sand-hill streams. Saline River joins Smoky Hill River a short distance below Salina and 9 miles, by railroad, above the mouth of Solomon River. The station, established May 4, 1897, is located at a bridge 4.5 miles northeast of Salina, near the mouth of the river. The rod of the wire gage is spiked to the floor of the bridge. Bench mark No. 1 is a nail in an elm tree 2 feet in diameter on the north side of the river and 6 feet west of the bridge. Its elevation is 22.90 feet above gage datum. Bench mark No. 2 is six nails driven into a 16-inch box-elder tree on the north side of the river and 35 feet east of the bridge. Its elevation is 22.90 feet above gage datum. The channel is straight for a little distance above and below the station. Both banks are high and not liable to overflow. The bed of the stream is sand and mud. The results of measurements may be found as follows: 1897, Ninteenth Annual Report, Part IV, page 346; 1898, Twentieth Annual Report, Part IV, page 316. The following discharge measurements for 1899 were made by W. G. Russell:

April 21, gage height, 2.90 feet; discharge, 26 second-feet.
May 27, gage height, 4.20 feet; discharge, 90 second-feet.
May 29, gage height, 12.65 feet; discharge, 1,007 second-feet.
May 30, gage height, 9.30 feet; discharge, 524 second-feet.
June 16, gage height, 8.60 feet; discharge, 560 second-feet.

aily gage height, in feet, of Saline River at Salina, Kansas, for 1899.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
..	.....	.....	.....	3.35	2.90	4.55	8.95	4.25	3.55	3.20	4.80	3.60
..	3.90	3.30	3.50	3.35	2.90	4.00	7.85	4.35	3.90	3.05	4.90	3.40
..	.....	.....	.....	3.35	3.70	9.95	6.95	4.55	3.75	3.10	4.10	3.60
..	3.80	3.20	.....	3.25	3.70	23.95	6.50	4.50	3.60	3.30	3.90	3.80
..	.....	.....	4.05	3.25	2.95	21.30	6.25	4.35	3.50	3.25	3.70	3.80
..	.....	.....	3.95	3.20	2.90	17.50	6.05	4.25	3.35	3.10	3.70	3.60
..	3.40	3.20	4.00	3.45	3.10	10.50	6.65	4.00	3.30	3.05	3.60	3.60
..	.....	.....	3.75	3.40	3.05	11.40	7.20	3.90	3.30	3.15	3.50	3.60
..	3.60	3.20	3.50	3.35	3.00	21.70	7.05	3.85	3.35	3.00	3.50	3.60
..	.....	3.30	3.80	3.35	2.80	27.15	6.15	3.80	3.35	3.00	3.50	3.60
..	3.70	3.30	3.75	3.30	2.70	23.50	7.55	3.80	3.25	3.00	3.50	3.80
..	.....	.....	3.65	3.35	2.60	21.20	10.05	3.80	3.20	3.20	3.40	3.60
..	.....	.....	4.10	3.10	2.70	15.10	8.60	4.15	3.30	3.10	3.60	3.60
..	3.80	3.10	3.70	3.30	3.00	8.40	6.45	4.10	3.25	3.05	3.60	3.70
..	.....	.....	3.70	3.25	2.95	7.25	6.15	3.95	3.30	3.05	3.50	3.80
..	.....	3.20	3.95	3.15	2.85	8.85	6.00	3.80	3.40	3.15	3.50	3.60
..	3.50	.....	3.75	3.15	2.90	13.45	6.20	3.75	3.55	3.05	3.60	3.90
..	.....	3.10	3.65	2.95	2.85	9.95	5.50	4.05	3.55	3.00	3.50	3.90
..	3.50	.....	3.65	3.00	2.75	7.25	5.30	4.05	3.35	3.10	3.60	3.80
..	.....	.....	3.35	3.00	2.85	5.80	5.15	3.85	3.35	3.05	3.50	3.70
..	3.70	3.30	3.35	2.80	2.75	5.35	4.95	3.70	3.35	3.10	3.60	3.60
..	.....	.....	3.45	3.00	4.35	5.10	4.85	3.65	3.25	3.20	3.60	3.70
..	3.20	3.40	3.15	3.10	11.35	5.40	4.65	3.55	3.25	3.10	3.60	3.60
..	.....	.....	3.25	3.10	9.40	7.50	4.60	3.60	3.35	3.05	3.70	3.40
..	.....	3.40	3.30	3.05	5.70	12.35	4.55	3.55	3.20	3.45	3.60	3.60
..	3.30	.....	3.30	3.10	4.75	15.30	4.45	3.60	3.15	4.00	3.60	3.80
..	.....	.....	3.35	3.05	4.20	17.70	4.35	3.55	3.25	3.65	3.70	3.60
..	3.30	3.90	3.10	2.90	6.85	19.65	4.35	3.50	3.25	3.35	3.50	3.60
..	.....	.....	3.15	2.85	12.60	20.05	4.30	3.30	3.30	7.30	3.60	3.60
..	.....	.....	3.20	2.95	8.15	14.25	4.35	3.25	3.25	6.60	3.80	3.60
..	3.30	.....	3.50	.....	5.20	.....	4.35	3.25	.....	5.50	.....	3.50

SMOKY HILL RIVER AT ELLSWORTH, KANSAS.

; river rises in eastern Colorado, and flows easterly, joining epublican River at Junction to form the Kansas River. The ; station, established April 17, 1895, is located at the highway on Douglass avenue, Ellsworth, Kansas. The gage is an ed ash timber spiked to a post driven in the bed of the river olted to an iron post on the bridge pier. The bench mark is a riven in the base of a large box-elder tree near the southeast of the bridge, 90 feet from the gage, and its elevation is 13.07 bove the zero of the gage. A slope gage is spiked to the Saint and San Francisco Railroad bridge 2,536 feet upstream, and is ed to the same datum. The channel is nearly straight above elow the gage, and the bed is sandy and shifting. The results of urements may be found as follows: 1896, Eighteenth Annual t, Part IV, page 214; 1897, Nineteenth Annual Report, Part IV, 347; 1898, Twentieth Annual Report, Part IV, page 315. Measents for 1899 were made by W. G. Russell, as follows:

March 20, gage height, 1.25 feet; discharge, 35 second-feet.
June 6, gage height, 2.07 feet; discharge, 184 second-feet.
June 26, gage height, 1.95 feet; discharge, 189 second-feet.
July 7, gage height, 4.75 feet; discharge, 1,675 second-feet.
July 8, gage height, 13 feet; discharge, 10,986 second-feet.
July 8, gage height, 10.95 feet; discharge, 7,348 second-feet.

Daily gage height, in feet, of Smoky Hill River at Ellsworth, Kansas, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	1.20	1.17	0.98	0.88	1.58	2.25	1.40	1.13	1.30	1.20
2	.....	.....	1.40	1.17	.95	.90	1.38	2.13	1.33	1.10	1.30	1.20
3	1.40	.....	1.50	1.10	.90	5.00	2.33	2.05	1.33	1.30	1.25	1.15
4	.....	1.30	1.45	1.13	.93	3.25	2.33	1.98	1.33	1.10	1.25	1.15
5	1.40	.....	1.30	1.17	.95	1.98	2.00	1.95	1.30	1.10	1.25	1.15
6	.....	.....	1.20	1.23	.98	3.20	1.83	1.88	1.28	1.30	1.20	1.10
7	1.50	1.30	1.30	1.20	.98	4.10	8.60	1.80	1.20	1.50	1.20	1.10
8	.....	.....	1.20	1.17	1.00	3.00	11.35	1.73	1.28	1.50	1.25	1.15
9	.....	.....	1.38	1.15	.95	7.70	6.00	1.73	1.38	1.30	1.25	1.15
10	1.50	.....	1.35	1.17	.93	5.70	5.10	1.73	1.50	1.30	1.25	1.20
11	.....	1.30	1.30	1.17	.93	3.45	4.58	1.68	1.38	1.30	1.25	1.20
12	1.50	.....	1.35	1.17	.93	2.80	3.80	1.60	1.35	1.10	1.20	1.15
13	1.40	1.50	1.40	1.23	1.00	2.20	3.33	1.95	1.50	1.10	1.20	1.15
14	1.05	.....	1.43	1.17	.95	2.00	2.85	1.78	1.50	1.50	1.20	1.20
15	1.20	1.50	1.45	1.20	.98	1.90	2.70	1.68	1.48	1.50	1.15	1.20
16	1.30	.....	1.35	1.17	.95	1.75	2.60	1.63	1.45	1.10	1.15	1.20
17	1.10	1.50	1.38	1.10	.90	1.60	2.70	1.60	1.48	1.10	1.15	1.25
18	1.30	.....	1.30	1.08	.95	1.60	2.40	1.55	1.40	1.50	1.10	(a)
19	1.40	1.50	1.28	1.08	.90	1.53	2.28	1.50	1.33	1.50	1.15	1.25
20	1.25	1.50	1.28	1.08	1.00	1.50	2.23	1.43	1.30	1.05	1.15	(a)
21	1.35	1.55	1.23	1.03	.95	1.45	2.18	1.40	1.28	1.05	1.20	(a)
22	1.35	1.45	1.23	1.03	.93	1.40	2.23	1.40	1.23	1.25	1.25	1.20
23	1.35	1.45	1.13	1.05	.95	3.15	2.23	1.33	1.23	1.25	1.20	1.20
24	1.20	1.40	1.17	1.03	1.03	2.85	2.20	1.30	1.20	1.30	1.20	1.20
25	1.15	1.40	1.15	1.03	1.10	2.25	2.13	1.35	1.20	1.40	1.25	1.15
26	1.30	1.40	1.17	1.03	1.13	2.15	2.10	3.85	1.15	1.75	1.25	1.20
27	1.20	1.40	1.15	1.00	1.08	1.90	2.05	2.75	1.15	1.58	1.20	1.20
28	1.30	1.45	1.15	1.00	.98	2.00	2.35	2.35	1.13	1.50	1.20	(a)
29	1.30	.....	1.10	1.00	.90	1.95	2.90	1.65	1.10	1.45	1.20	1.20
30	1.30	.....	1.20	.98	.93	1.80	2.45	1.50	1.10	1.45	1.20	1.25
31	.....	.....	1.17	.....	.88	.....	2.30	1.43	.....	1.35	.....	1.20

a Frozen.

BLUE RIVER AT MANHATTAN, KANSAS.

This stream is one of the principal tributaries of Kansas River, and drains a part of southeastern Nebraska and northeastern Kansas. It enters Kansas River at Manhattan. Its tributaries extend almost to the Platte River. The drainage basin receives a copious rainfall, and therefore the run-off is considerably larger than from the more western tributaries of Kansas River. The gaging station, established April 12, 1895, is at the county bridge 4 miles north of Manhattan. The gage rod consists of three sections, the lower being an ash stick driven into the bottom of the river and bolted to an overhanging cottonwood tree 30 feet east of the bridge. The other two sections of the rod are bolted to the south bridge pier. The bench mark is a cross cut in the capstone of the south bridge pier immediately above the upper gage, and is 32.135 feet above gage datum. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 218; 1897, Nineteenth Annual Report, Part IV, page 348; 1898, Twentieth Annual Report, Part IV, page 319. The following discharge measurements were made by W. G. Russell during 1899:

April 20, gage height, 4.60 feet; discharge, 767 second-feet.
May 23, gage height, 13.70 feet; discharge, 8,952 second-feet.
June 8, gage height, 16.60 feet; discharge, 20,237 second-feet.
June 9, gage height, 18.30 feet; discharge, 19,529 second-feet.
June 10, gage height, 15.60 feet; discharge, 13,616 second-feet.
October 18, gage height, 3.70 feet; discharge, 366 second-feet.

ily gage height, in feet, of Blue River at Manhattan, Kansas, for 1899.

r.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
...	4.50	4.80	4.65	4.95	4.88	5.70	6.85	7.05	4.20	3.80	4.25	4.00
...	4.40	4.70	4.65	4.85	5.45	5.95	6.25	5.90	4.15	3.80	4.25	3.95
...	4.40	4.60	4.95	4.75	5.35	12.85	6.85	5.25	4.30	3.80	4.15	4.05
...	4.40	4.70	5.75	4.85	6.05	23.00	6.35	4.90	4.25	3.80	4.05	4.10
...	4.40	4.85	5.80	4.90	5.90	12.65	5.85	5.15	4.15	3.80	4.00	3.95
...	4.50	4.90	5.70	5.15	5.10	8.40	8.35	6.75	4.00	3.80	4.00	4.00
...	4.45	4.80	5.60	5.45	4.75	7.60	10.65	6.00	4.05	3.80	4.15	3.95
...	4.45	4.75	6.00	5.65	5.10	13.95	14.25	5.20	4.05	3.85	4.10	3.90
...	4.45	4.70	6.05	5.65	5.95	18.25	12.90	5.00	4.20	3.80	4.10	4.00
...	4.45	4.80	6.10	5.45	10.55	15.80	10.60	4.70	4.30	3.75	4.10	4.15
...	4.60	4.85	7.40	5.30	10.25	11.25	9.00	4.70	4.10	3.85	4.10	4.20
...	4.75	4.90	7.35	5.15	6.40	8.75	8.35	4.65	4.05	3.80	4.10	4.30
...	4.75	4.80	6.40	5.00	5.80	8.05	7.40	7.00	3.90	3.80	4.05	3.95
...	4.65	4.80	6.00	5.00	5.40	7.20	7.25	11.45	3.95	3.80	4.05	3.75
...	4.55	4.90	9.00	4.95	5.00	6.83	6.55	9.25	3.95	8.80	3.95	4.55
...	4.50	4.60	12.20	4.85	5.00	6.50	6.60	9.20	4.00	3.95	4.05	4.30
...	4.50	4.65	9.95	4.75	5.05	6.60	6.60	8.15	4.00	3.80	4.20	4.45
...	4.50	4.60	8.35	4.75	4.80	6.75	6.10	7.00	3.75	3.80	4.20	4.20
.	4.40	4.65	7.25	4.70	4.30	6.90	5.75	6.10	3.75	3.80	4.20	4.10
...	4.40	4.75	6.60	4.58	13.10	6.95	5.60	5.60	3.90	3.80	4.15	3.90
...	4.45	4.70	6.25	4.53	21.55	6.70	5.50	5.30	3.95	3.75	4.00	4.10
...	4.50	4.75	6.15	4.48	22.85	6.55	5.25	4.90	3.90	3.95	4.00	4.10
...	4.50	4.90	5.90	4.50	13.50	6.25	5.15	4.80	3.90	3.45	3.95	4.15
...	4.50	5.25	5.55	4.50	9.40	6.15	5.10	4.80	3.90	3.80	3.90	4.05
...	4.40	5.20	5.40	4.50	8.30	6.35	4.95	4.50	3.90	3.90	4.05	4.15
...	4.40	5.20	5.25	4.43	9.10	6.40	4.90	4.20	3.80	7.05	4.10	3.95
...	4.50	5.10	5.25	4.45	9.65	6.30	4.85	3.50	3.90	6.80	4.05	3.90
...	4.50	4.95	5.20	5.63	7.25	7.35	5.05	4.50	3.80	5.65	4.05	3.85
...	4.80	.....	5.05	5.70	6.45	6.45	6.90	4.45	3.80	4.95	4.05	3.70
...	4.85	.....	5.05	5.20	6.00	6.45	12.00	4.35	3.80	4.70	4.05	3.70
...	4.90	.....	5.00	.....	6.10	.....	8.25	4.40	.....	4.40	.....	4.05

KANSAS RIVER AT LECOMPTON, KANSAS.

s river, formed by the junction of Republican and Smoky Hill , at Junction, Kansas, flows in a general easterly direction into uri River at Kansas City. The gaging station at Lecompton stablished April 16, 1899, and is located at the new carriage e recently built across the river.

• following discharge measurements were made by E. C. Murphy V. G. Russell during 1899:

Measurements of Kansas River at Lecompton, Kansas.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-feet.*
·. 7	3.40	2,935	June 5	9.90	21,762
·. 15	3.35	2,747	June 12	6.60	11,549
·. 21	3.15	2,251	June 16	3.52	4,326
·. 29	5.90	8,744	July 17	6.30	10,500
y 11	6.35	10,859	July 28	3.95	3,349
y 25	11.20	34,213	Oct. 10	2.00	1,889

Daily gage height, in feet, of Kansas River at Lecompton, Kansas, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.40	4.50	5.45	5.55	2.60	2.00	2.90	2.10
2	.....	3.35	4.15	6.25	4.45	2.60	2.00	2.80	2.10
3	.....	3.20	4.00	6.20	4.15	2.60	2.00	2.70	2.10
4	.....	3.20	7.10	6.00	3.95	2.60	2.00	2.60	2.10
5	.....	3.20	9.50	5.90	3.85	2.50	2.00	2.50	2.10
6	.....	3.20	8.90	5.75	4.85	2.50	2.00	2.50	2.05
7	.....	3.40	7.90	9.05	4.50	2.40	2.00	2.40	2.00
8	.....	3.40	7.25	11.00	4.40	2.40	2.00	2.40	2.00
9	.....	3.40	9.25	8.85	4.30	2.30	2.00	2.40	2.00
10	.....	3.55	10.00	8.50	3.90	2.30	2.00	2.30	2.00
11	.....	5.80	9.00	7.80	3.50	2.30	2.00	2.30	2.15
12	.....	6.15	7.80	6.70	3.50	2.30	2.00	2.30	2.25
13	.....	5.25	7.30	6.20	3.50	2.30	1.90	2.30	2.45
14	.....	4.45	6.90	5.90	4.00	2.30	1.90	2.30	2.65
15	.....	3.95	6.65	6.40	5.40	2.20	1.90	2.30	2.90
16	3.50	3.65	6.55	6.60	5.50	2.20	1.90	2.30	3.00
17	3.40	3.50	6.10	6.25	5.10	2.20	1.90	2.30	3.00
18	3.30	3.35	5.30	5.85	4.75	2.20	1.90	2.30	2.90
19	3.20	3.30	5.00	5.30	4.40	2.20	1.90	2.20	2.90
20	4.70	3.35	4.95	4.80	4.15	2.20	1.90	2.20	2.80
21	3.40	8.00	4.85	4.45	3.80	2.20	1.90	2.20	2.70
22	3.40	(a)	4.65	4.25	3.55	2.10	1.90	2.20	2.65
23	3.40	(a)	4.50	4.05	3.45	2.10	1.90	2.20	2.60
24	3.40	7.50	4.50	3.85	3.25	2.10	1.90	2.20	2.60
25	3.30	6.15	4.80	3.70	3.05	2.10	1.90	2.20	2.60
26	3.20	5.65	4.90	3.60	2.90	2.10	1.90	2.20	2.50
27	3.20	5.10	5.05	3.60	2.90	2.00	2.05	2.20	2.50
28	3.20	5.90	5.35	3.50	2.90	2.00	2.45	2.10	2.45
29	3.20	6.45	5.55	3.45	2.80	2.00	2.75	2.10	2.40
30	3.20	5.10	5.70	5.15	2.80	2.00	3.00	2.10	2.40
31	.....	4.75	.....	5.30	2.70	.....	3.00	.....	2.40

a Water over gage.

KANSAS RIVER AT LAWRENCE, KANSAS.

The station at this point, 11 miles below the Lecompton station, was established in July, 1895, and is located at the wagon bridge at Lawrence, Kansas. The gage was fastened to the south pier of the bridge, about 50 feet up the river from the crest of the dam. Owing to the impossibility of accurately rating this station, no measurements of discharge were made here during 1899, but gage readings were maintained until November 4, when the station was discontinued. The Lecompton station was established to take the place of this one. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 220; 1897, Nineteenth Annual Report, Part IV, page 350; 1898, Twentieth Annual Report, Part IV, page 322.

Daily gage height, in feet, of Kansas River at Lawrence, Kansas, for 1899.

[Sign — indicates that water is below zero of gage.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	0.50	—1.75	.80	1.20	1.20	2.00	2.35	2.85	0.60	0.10	0.80
2	.60	— .50	1.10	1.20	1.00	1.90	2.70	1.95	.60	.15	.75
3	.60	.00	.90	1.20	1.00	2.10	2.95	1.65	.60	.20	.75
4	.80	.10	1.05	1.20	.85	2.70	2.80	1.55	.60	.20	.65
5	.90	.00	2.00	1.25	.85	5.60	2.65	1.40	.60	.20	.....
6	.70	.40	1.80	1.35	.90	5.50	2.55	1.50	.55	.20	.....
7	.65	— .70	.70	1.60	1.20	3.75	4.50	1.80	.50	.20	.....
8	.80	— .60	.90	1.60	1.10	3.50	6.55	1.90	.50	.20	.....
9	.60	.00	1.05	1.80	1.00	4.60	4.80	1.50	.50	.10	.....
10	.50	— .50	1.30	1.75	1.20	6.20	4.50	1.40	.50	.00	.....
11	.45	— .80	1.30	1.60	2.90	6.30	3.55	1.30	.50	.00	.....
12	.50	— .20	2.80	1.45	2.80	5.40	3.00	1.25	.50	.00	.....
13	.50	— .60	2.90	1.40	2.60	4.10	2.55	1.10	.50	—.10	.....
14	.50	—1.20	2.80	1.25	1.80	3.80	2.65	1.35	.40	—.20	.....
15	.50	—1.20	2.60	1.10	1.45	3.50	2.75	1.90	.40	—.20	.....
16	.45	—1.40	3.70	1.00	1.20	3.10	3.00	2.65	.35	—.30	.....
17	.40	— .15	3.60	1.00	1.00	2.80	3.00	2.25	.40	—.20	.....
18	.40	.00	3.50	.90	1.00	2.15	2.70	2.05	.40	—.20	.....
19	.40	.50	2.80	.80	1.00	2.00	2.25	1.70	.35	—.20	.....
20	.55	.50	2.10	2.70	1.00	2.00	1.95	1.50	.30	—.20	.....
21	.75	.55	1.80	1.35	3.40	1.95	1.80	1.35	.30	—.20	.....
22	.80	.35	1.80	1.00	5.65	1.85	1.60	1.15	.30	—.30	.....
23	.75	.00	1.55	1.00	5.80	1.70	1.60	1.00	.30	—.30	.....
24	.75	— .20	1.50	1.00	4.80	1.90	1.50	1.00	.30	—.30	.....
25	.70	.00	1.40	1.00	3.10	2.00	1.40	.85	.30	—.35	.....
26	.80	.50	1.40	1.00	2.50	2.00	1.40	.85	.20	—.35	.....
27	.65	.70	1.40	1.00	2.10	2.10	1.25	.80	.10	—.30	.....
28	.35	.80	1.35	1.00	2.70	2.40	1.15	.80	.05	—.35	.....
29	.60	.....	1.20	1.00	3.10	2.40	1.10	.80	.00	+.80	.....
30	.40	.....	1.20	1.40	2.60	2.40	1.80	.75	.00	.85	.....
31	.60	.....	1.20	.....	1.90	.....	2.35	.65	.....	.85	.....

Station discontinued October 31.

ARKANSAS RIVER.

The source of this river is in the vicinity of Tennessee Pass, in the ıtral portion of Colorado. It flows southerly for about 70 miles, ɜn easterly for 50 miles to Canyon, receiving a number of tributa- s from the mountainous area on either side, which tends to increase ɜ discharge of the river. At Canyon it suddenly emerges from the ɔcky Mountain front and thence flows in an easterly direction, trav- ɜing the Great Plains of eastern Colorado, in which section most of ɜ water is diverted for irrigation. After crossing the Kansas line continues eastward for about 200 miles until the center of the State reached, when it suddenly bends to the southward and passes into dian Territory, and from thence into the State of Arkansas, finally ıtering the Mississippi River about 25 miles above Greenville, Mis- ssippi. Throughout the mountainous area above Canyon the dis- ıarge increases, but as soon as the river emerges onto the Great Plains ɜ water is gradually diverted by means of canals, so that by the me the Kansas line is reached the river is usually dry during the ımmer stages. In its mountainous course the river makes a descent om 10,000 feet at Leadville to 5,300 feet at Canyon, a distance of 0 miles.

During the last year two notable examples of engineering construc- ɜn have been practically completed in this basin. The first one is ɜ Twin Lakes reservoir, in which a dam 30 feet in height, of solid

masonry, has been completed in a cut below the outlet of the lower lake of Twin Lakes, which is one source of supply of the Arkansas. This is designed to store water for a canal 130 miles below, which heads a few miles below Pueblo. The ditch has been cleaned out during the last season, and it is stated that $2,000,000 are being spent on a sugar-beet factory receiving water from it.

Twelve miles north of Lamar, Colorado, are a series of depressions in the plains, separated by ridges. Five of these have been connected by ditches, making the continuous reservoir system of The Great Plains Water Company. Their total available capacity is 194,562 acre-feet. It is the intention to fill them from the Arkansas River during the winter and high-water seasons by means of a supply ditch, which is now completed. This ditch is about 90 miles long and heads immediately above La Junta. Its capacity at the head is 2,000 second-feet. A number of gaging stations have been maintained in this drainage basin, and they are described in order down stream:

LAKE CREEK AT TWIN LAKES, COLORADO.

This creek enters the Arkansas a short distance above Granite, Colorado. The station was established June 21, 1899, by Mr. O. O. McReynolds, chief engineer of the Colorado Land and Water Company, which has been at work on the reservoir of Twin Lakes during the last year. It was at first contemplated that measurements should be made showing the discharge into the upper lake, between the two lakes, and below the lower lake, but owing to difficulties encountered only a few measurements were made at the two upper points. On July 17 the discharge entering the upper lake, at a gage height of 2.80 feet, was found to be 273 second-feet; on October 12, at the same point, with a gage height of 1.9 feet, the discharge was 27 second-feet. Three measurements of discharge were made at a point between the two lakes: June 21, at a gage height of 3.60 feet, the discharge was found to be 1,007 second-feet; July 17, at a gage height of 1.90 feet, the discharge was 374 second-feet; October 12, gage height, 1.4 feet; discharge, 42 second-feet. A number of discharge measurements at the lower station were made, sufficient for the construction of a rating table covering the period from June 21 to July 20, but after that date the surface of the lakes was raised and lowered periodically through the operations of a placer company which had constructed a dam below the lower lake. The following measurements of discharge were made by A. L. Fellows and O. O. McReynolds during 1899:

June 21, gage height, 3.80 feet; discharge, 1,208 second-feet.
June 27, gage height, 3.20 feet; discharge, 696 second-feet.
July 17, gage height, 2.55 feet; discharge, 391 second-feet.
July 24, gage height, 2.50 feet; discharge, 344 second-feet.
August 14, gage height, 2.50 feet; discharge, 183 second-feet.
October 13, gage height ——; discharge, 22 second-feet.

Daily gage height, in feet, of Lake Creek at Twin Lakes, Colorado, for 1899.

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	.....	3.10	2.72	2.15	12	.....	2.65	2.60	.....	23	3.65	2.50	2.30	.....
2	.....	3.15	2.72	2.10	13	.....	2.75	2.55	.....	24	3.50	2.52	2.30	.....
3	.....	3.10	2.78	2.10	14	.....	2.65	2.50	.....	25	3.40	2.50	2.25	.....
4	.....	3.05	2.88	2.10	15	.....	2.55	2.48	.....	26	3.30	2.45	2.25	.....
5	.....	2.95	2.95	2.05	16	.....	2.50	2.45	.....	27	3.20	2.48	2.22	.....
6	.....	2.95	2.98	2.05	17	.....	2.50	2.45	.....	28	3.10	2.55	2.20	.....
7	.....	2.90	2.90	2.05	18	.....	2.50	2.45	.....	29	3.10	2.65	2.15	.....
8	.....	2.85	2.88	2.05	19	.....	2.50	2.40	.....	30	3.10	2.70	2.15	.....
9	.....	2.80	2.85	2.00	20	.....	2.50	2.40	.....	31	.....	2.70	2.15	.....
10	.....	2.75	2.75	2.00	21	3.80	2.55	2.40	.....					
11	.....	2.70	2.65	2.00	22	3.70	2.55	2.35	.....					

ARKANSAS RIVER AT GRANITE, COLORADO.

This station is located at the wagon bridge, 250 feet from the railroad station at Granite, Colorado. The gage is a vertical 2 by 6 inch plank spiked to the upper end of the center pier of the bridge. The banks are low and liable to overflow; the bed is rocky, and the current swift. It will be impossible to construct a rating table for this station from the measurements obtained in 1899. The results of measurements may be found as follows: 1897, Nineteenth Annual Report, Part IV, page 354; 1898, Twentieth Annual Report, Part IV, page 330. The following discharge measurements were made by A. L. Fellows during 1899:

May 25, gage height, 5 feet; discharge, 1,476 second-feet.
July 15, gage height, 2.80 feet; discharge, 1,178 second-feet.
October 14, gage height, 1.60 feet; discharge, 130 second-feet.

Daily gage height, in feet, of Arkansas River at Granite, Colorado, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	3.15	3.90	5.80	3.90	2.40	2.00
2	.....	3.25	3.80	5.75	3.90	2.40	2.00
3	.....	3.25	3.80	5.25	3.90	2.40	2.00
4	.....	2.25	3.80	4.80	3.80	2.60	2.00
5	.....	3.20	3.80	4.50	3.50	2.60	2.00
6	.....	3.20	3.80	4.60	3.50	2.60	2.00
7	.....	3.20	3.90	4.85	3.45	2.60	2.00
8	.....	3.15	3.95	5.00	3.40	2.60	2.00
9	.....	3.25	4.05	5.00	3.40	2.60	2.00
10	.....	3.35	4.20	5.00	3.40	2.40	2.00
11	.....	3.45	4.35	5.40	3.35	2.40	.....
12	.....	3.45	4.00	6.70	3.30	2.40	.....
13	.....	3.50	4.95	6.95	3.00	2.40	.....
14	.....	3.50	5.40	6.90	3.00	2.40	.....
15	.....	3.50	5.80	6.40	2.80	2.40	.....
16	.....	3.50	5.80	6.00	2.80	2.00	.....
17	.....	3.50	5.80	5.85	2.80	2.00	.....
18	.....	3.50	5.90	5.75	2.80	2.00	.....
19	.....	3.50	5.90	5.85	2.80	2.00	.....
20	.....	3.50	5.75	5.85	2.80	2.00	.....
21	.....	3.50	5.65	5.70	2.80	2.00	.....
22	.....	3.55	5.00	5.65	2.80	2.00	.....
23	3.30	3.65	4.80	5.00	2.80	2.00	.....
24	3.15	3.65	4.95	4.85	2.80	2.00	.....
25	3.20	3.75	5.00	4.60	2.80	2.00	.....
26	3.25	3.95	5.35	4.40	2.80	2.00	.....
27	3.25	4.00	5.65	4.00	2.60	2.00	.....
28	3.25	4.00	5.75	3.90	2.60	2.00	.....
29	3.20	3.90	5.60	3.90	2.60	2.00	.....
30	3.10	3.90	5.90	3.90	2.60	2.00	.....
31	3.15	.....	6.00	.....	2.60	2.00	.....

ARKANSAS RIVER AT SALIDA, COLORADO.

This station was established April 11, 1895, and is located at the suspension bridge at Salida, Colorado. The gage consists of a vertical timber bolted to the abutment of the bridge; the banks are high and do not overflow; the bed of the stream consists of sand and gravel. Large bowlders interfere to a considerable extent with the accuracy of the results. Results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 224; 1897, Nineteenth Annual Report, Part IV, page 355; 1898, Twentieth Annual Report, Part IV, page 331. The following discharge measurements were made by A. L. Fellows during 1899:

April 26, gage height, 1.72 feet; discharge, 686 second-feet.
May 25, gage height, 3.10 feet; discharge, 1,999 second-feet.
July 14, gage height, 2.40 feet; discharge, 1,801 second-feet.
November 8, gage height, 0.80 feet; disharge, 317 second-feet.

Daily gage height, in feet, of Arkansas River at Salida, Colorado, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	0.80	1.30	3.25	3.20	1.60	0.80
2	.....	.80	1.35	3.35	3.20	1.60	.80
3	.....	.80	1.25	3.10	3.20	1.70	.80
4	.....	.80	1.20	2.85	3.20	2.40	.70
5	.....	.85	1.25	2.65	3.10	2.10	.70
6	.....	.80	1.40	2.60	3.20	2.15	.60
7	.....	.80	1.50	2.85	3.05	1.85	.60
8	.....	.80	1.65	2.90	2.90	1.65	.55
9	.....	.85	1.95	3.05	2.50	1.45	.50
10	.....	.95	2.05	3.20	2.45	1.40	.50
11	.....	1.00	2.10	3.50	2.40	1.35	.50
12	.....	1.02	2.25	3.60	2.35	1.15	.50
13	.....	1.10	2.45	3.70	2.65	1.20	.75
14	.....	1.00	2.70	4.00	2.35	1.20	.90
15	.....	1.05	2.85	4.30	2.45	1.20	1.00
16	.....	1.20	2.90	4.85	2.40	1.20	1.00
17	.....	1.20	2.90	5.00	2.80	1.10	.80
18	.....	1.10	2.95	4.85	2.50	1.10	.70
19	.....	1.15	3.00	4.95	2.40	1.05	.65
20	.....	.95	3.00	5.10	2.30	1.00	.55
21	.....	.90	2.80	5.00	2.00	1.00	.50
22	0.80	.95	2.60	4.50	1.85	.90	.50
23	.80	1.10	2.45	4.20	1.80	.80	.50
24	.80	1.20	2.50	4.20	1.85	.80	.50
25	.80	1.30	2.75	4.10	1.65	.80	.50
26	.90	1.55	2.95	3.85	1.60	.70	.50
27	.70	1.60	3.10	3.50	1.65	.70	.40
28	.70	1.65	3.10	3.20	1.55	.70	.40
29	.70	1.50	3.10	3.20	1.40	.70	.40
30	.70	1.40	3.20	3.20	1.50	.70	.40
31	.70	.....	3.25	.....	1.60	.90	.....

Closed for the winter September 30.

ARKANSAS RIVER AT CANYON, COLORADO.

This station, established in 1889, is located at the Hot Springs Hotel, 1½ miles west of Canyon and about 500 yards below the mouth of Grape Creek. The gage rod is placed on the left bank of the river, just below the suspension foot bridge, and consists of an inclined 4 by 4 inch timber bolted to posts set in the ground. The station is an important one, as it is located at the mouth of the canyon and

above most of the canal diversions. The only two ditches taking water above the gaging station are the North and South Side ditches, which were each measured three times during 1899, as follows: On April 27, August 18, and November 7. North Side ditch, on the first date, was carrying 55 second-feet, and the South Side ditch 48 second-feet; on the second date North Side ditch was discharging 35 second-feet and the South Side ditch 43 second-feet; at the third measurement of discharge the North Side ditch showed 28 second-feet and the South Side 36 second-feet. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 226; 1897, Nineteenth Annual Report, Part IV, page 356; 1898, Twentieth Annual Report, Part IV, page 331. The discharge measurements were made by A. L. Fellows for 1899, as follows:

April 27, gage height, 3.20 feet; discharge, 611 second-feet.
May 26, gage height, 4.55 feet; discharge, 2,189 second-feet.
July 7, gage height, 4.50 feet; discharge, 2,651 second-feet.
August 18, gage height, 2.90 feet; discharge, 553 second-feet.
November 7, gage height, 2.55 feet; discharge, 306 second-feet.

Daily gage height, in feet, of Arkansas River at Canyon, Colorado, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1				2.80	3.25	5.00	5.00	3.60	2.60			
2				2.80	3.10	5.05	5.30	3.50	2.50			a2.70
3				2.80	3.05	5.00	5.00	3.50	2.50			
4		2.60	3.40	2.80	2.90	4.75	4.85	4.10	2.50	a2.20	a2.60	
5				2.80	2.90	4.50	4.75	4.45	2.40			
6	2.60			2.80	2.90	4.45	4.60	3.65	2.40			
7				2.70	3.00	4.65	4.55	3.50	2.30			
8				2.70	3.15	4.70	4.40	3.50	2.30			
9				2.70	3.35	4.75	4.30	3.40	2.30			a2.70
10				2.75	3.55	4.85	4.20	3.30	2.30			
11		2.50	3.00	2.80	3.65	5.05	4.10	3.10	2.20	a2.40	a2.80	
12				3.00	3.90	5.45	4.05	3.00	2.20			
13				3.00	4.25	5.85	4.45	3.00	2.20			
14	2.60			3.05	4.50	6.00	4.25	3.00	2.20			
15				3.00	4.70	5.95	4.25	2.90	2.30			
16				3.05	4.80	5.95	4.40	2.80	2.30			a2.50
17				3.00	4.85	5.95	4.10	2.95	2.60			
18		2.10	2.70	3.00	4.65	6.05	4.05	2.90	2.50		a2.90	
19				2.95	4.75	6.10	4.50	2.85	2.40			
20				3.00	4.80	6.10	4.10	2.80	2.40	a2.40		
21	2.60			2.75	4.65	6.05	3.90	2.70	2.30			
22				2.70	4.40	5.95	3.80	2.70	2.30			
23				2.75	4.20	5.75	3.70	2.60	2.30			a2.50
24				2.90	4.15	5.60	3.70	2.60	2.30			
25		3.00	2.70	3.05	4.50	5.50	3.60	2.50	2.30		a3.00	
26				3.20	4.60	5.30	3.50	2.50	2.30			
27				3.30	4.80	5.25	3.50	2.50	2.20			
28	2.60			3.35	4.80	5.00	3.60	2.50	2.20	a2.50		
29				3.40	4.80	5.05	3.55	2.50	2.20			
30				3.25	4.90	4.95	3.65	2.40	2.20			a2.80
31					5.00		3.60	2.50				

a Average for week.

ARKANSAS RIVER AT PUEBLO, COLORADO.

This station was established in September, 1894, and is at present located at Main street bridge in the city of Pueblo. The gage is a by 6 inch plank bolted to the masonry wall at the south end of the bridge. The bench mark consists of a point on the stone coping at the south end of the bridge, and is 17.30 feet above gage datum.

Gage readings are furnished by the city engineer of Pueblo. results of measurements may be found as follows: 1896, Eighte Annual Report, Part IV, page 230; 1897, Nineteenth Annual Re Part IV, page 357; 1898, Twentieth Annual Report, Part IV, 336. The following discharge measurements for 1899 were under the direction of A. L. Fellows:

Measurements of Arkansas River at Pueblo, Colorado.

Date.	Gage height.	Dis-charge.	Date.	Gage height.	Dis char
1899.	*Feet.*	*Sec.-feet.*	1899.	*Feet.*	*Sec.-f*
Apr. 27	0.8	695	Aug. 5	1.46	1,9
May 26	2.2	2,221	Aug. 14	1.20	1,4
June 3	2.55	2,856	Sept. 16	−0.5	1
June 17	3.60	4,565	Sept. 18	−0.10	3
July 1	2.22	2,959	Oct. 6	−0.20	3
July 8	1.61	2,098	Nov. 7	0.05	6
Aug. 1	0.72	1,199			

Daily gage height, in feet, of Arkansas River at Pueblo, Colorado, for 18

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	D
1	0.40	0.36	0.59	0.49	0.75	2.50	2.10	c1.00	−0.23	(b)	0.05	−0
2	.35	.32	.75	.45	.80	2.50	2.10	.80	−.22	−0.35	.02	−
3	.30	.57	.59	.50	.80	2.50	2.40	.90	(b)	−.30	.07	
4	.55	.62	.68	.44	.60	2.20	2.10	1.15	−.20	−.31	.04	−
5	.55	.60	.60	.40	.55	1.90	1.90	1.55	−.25	−.26	(b)	−
6	.58	.62	.51	.47	.50	1.70	1.80	(b)	−.35	−.20	.00	−
7	.43	.60	.62	.47	.55	2.00	2.20	1.10	−.38	−.30	.05	−
8	.43	.62	.63	.47	.65	2.10	1.60	.97	−.40	(b)	.00	−
9	.45	.60	.59	.34	.65	2.20	1.50	.85	−.32	−.28	−.02	−
10	.47	.58	.61	.30	.75	2.30	1.40	.60	(b)	−.32	.01	
11	.39	.75	.47	.29	.85	2.40	1.20	.30	−.50	−.30	−.01	−
12	.37	.72	.45	.29	1.30	2.80	1.80	.35	−.48	−.33	(b)	−
13	.45	.70	.40	.40	1.70	3.30	2.00	(b)	−.60	−.35	.00	−
14	.48	.70	.27	.40	2.00	3.30	1.90	d1.90	−.55	−.20	−.02	
15	.49	1.05	.20	.45	2.15	3.60	1.90	.40	−.50	(b)	−.01	−
16	.49	1.05	.18	.50	2.25	3.70	1.65	.27	−.38	−.15	−.05	−
17	.50	1.19	.69	.50	2.25	3.60	1.50	.25	(b)	−.30	−.12	
18	.50	.95	.40	.50	2.35	3.50	1.80	.10	−.05	−.25	−.15	−
19	.50	.85	.40	.45	2.25	3.60	2.00	.07	−.20	−.28	(b)	−
20	.50	.72	.22	.40	2.45	3.80	1.50	(b)	−.18	−.25	−.13	
21	.47	.70	.30	.50	2.25	3.70	a1.30	−.05	−.15	−.20	−.15	−
22	.50	.70	.25	.20	2.05	3.70	1.10	−.20	−.25	(b)	−.16	
23	.55	.70	.20	.20	1.75	3.30	1.10	−.10	−.30	−.05	−.18	
24	.52	.45	.35	.20	1.65	2.90	1.10	−.15	(b)	−.11	−.10	
25	.45	.67	.35	.40	2.05	2.80	.90	−.30	−.35	−.15	−.08	
26	.40	.65	.45	.45	2.28	2.60	.80	−.35	−.39	−.03	(b)	
27	.30	.50	.45	.70	2.50	2.60	1.10	(b)	−.40	−.00	−.20	−
28	.37	.59	.31	.78	2.55	2.20	1.00	−.33	−.42	.02	−.22	−
29	.37	.....	.36	.90	2.45	2.20	.80	−.35	−.45	(b)	−.20	−
30	.37	.....	.33	.80	2.50	2.30	1.10	−.45	−.45	.03	(b)	−
31	.35	.....	.40	.....	2.50	.....	.90	−.40	.....	.03	.....	

a New rating table from June 21.
b No record.
c Gage heights after July 31 are from city engineer's records.
d August 19, storm in Pueblo; water rose to 7 feet in night.
e Ice gorge; discard readings.

ARKANSAS RIVER AT NEPESTA, COLORADO.

This station, established September 8, 1897, is located 1,00 north of Nepesta, Colorado, at a wagon bridge. The gage consi a vertical timber securely fastened to the upstream cylinder of b on the left side of the river. The channel above and below th

on is straight for several hundred feet, while the bed is sandy and ifting, and the results, therefore, are not altogether satisfactory for e purpose of making a rating table. This station is maintained by he Great Plains Water Company. The results of discharge measure-ents may be found as follows: 1897, Nineteenth Annual Report, art IV, page 358; 1898, Twentieth Annual Report, Part IV, page 37. The following discharge measurements were made under the irection of A. L. Fellows in 1899:

May 29, gage height, 4.60 feet; discharge, 1,810 second-feet.
June 7, gage height, 4.63 feet; discharge, 1,636 second-feet.
August 3, gage height, 4 feet; discharge, 610 second-feet.
August 25, gage height, 3.10 feet; discharge, 215 second-feet.
October 2, gage height, 3.12 feet; discharge, 213 second-feet.

Daily gage height, in feet, of Arkansas River at Nepesta, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		3.50	4.80	5.50	4.10	3.40	3.00	5.20	3.10
2		3.60	4.70	5.30	4.00	3.10	3.00	3.70	3.10
3		3.50	4.80	5.70	4.20	3.10	3.00	3.70	(b)
4		3.50	4.50	5.50	4.90	3.10	3.10	3.50	
5		3.40	4.30	5.20	5.80	3.00	3.20	3.20	
6		3.30	4.30	5.10	5.50	3.00	3.20	3.30	
7		3.40	4.70	5.00	5.10	3.00	3.20	3.50	
8		3.50	4.70	5.20	4.20	3.00	3.20	3.50	
9		3.50	4.70	4.90	4.20	3.00	3.10	3.50	
10		3.70	4.80	4.90	3.90	2.80	3.10	3.40	
11		3.70	5.00	4.50	3.60	3.00	2.90	3.50	
12		3.90	5.30	4.70	3.40	2.90	3.00	3.60	
13		4.50	5.20	4.20	3.20	2.90	3.10	3.50	
14		4.60	5.10	5.10	a7.50	2.80	3.30	3.50	
15		4.60	5.30	5.80	4.40	3.00	3.10	3.30	
16		4.60	5.50	6.00	3.50	3.40	3.00	3.30	
17		4.50	5.50	5.90	3.40	3.10	3.10	3.20	
18		4.60	5.40	5.50	3.10	3.30	3.20	3.30	
19		4.40	5.50	5.40	2.90	3.20	3.10	3.20	
20		4.50	5.60	5.20	3.40	3.10	3.10	3.20	
21	3.50	4.50	5.80	4.90	3.20	3.10	3.20	3.10	
22	3.40	4.50	5.70	4.70	3.30	3.10	3.20	3.10	
23	3.00	4.50	5.70	5.00	2.90	3.00	3.30	3.20	
24	3.20	4.40	5.50	5.80	3.00	3.00	3.30	3.20	
25	3.20	4.50	5.30	4.00	3.10	3.10	3.30	3.30	
26	3.30	4.70	5.20	4.00	3.00	3.00	3.40	3.10	
27	3.50	4.80	5.10	4.00	3.20	3.00	3.40	3.10	
28	3.50	4.80	5.10	5.00	3.20	2.90	3.50	3.00	
29	3.40	4.60	5.00	7.00	3.10	2.80	3.40	3.00	
30	3.40	4.60	5.10	4.90	3.00	2.90	3.40	3.00	
31		4.90		4.90	3.00		3.50		

a Flood at Pueblo. *b* Records discontinued December 2.

ARKANSAS RIVER AT ROCKYFORD, COLORADO.

This station is located 2 miles northeast of Rockyford, Colorado, and was established May 3, 1897. The gage consists of a vertical timber fastened to the abutment of the wagon bridge on the left side of the stream. Both banks are low, but not liable to overflow, excepting at very high water. The bed is sandy and shifting. S. W. Bressy, commissioner of Colorado irrigation district No. 17, is the voluntary observer. On October 16 Rockyford ditch near by was measured at the rating flume, at a gage height of 1.13 feet, and gave a discharge of 41 second-feet. The results of measurements may be

found as follows: 1898, Twentieth Annual Report, Part IV, page
The measurements for 1899, made by A. L. Fellows, are as follo

May 30, gage height, 1.88 feet; discharge, 1,042 second-feet.
October 16, gage height, 0.88 foot; discharge, 136 second-feet.

Daily gage height, in feet, of Arkansas River at Rockyford, Colorado, for

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	D
1	.....	1.34	1.10	2.12	2.10	1.82	0.81	0.68	1.70	
2	.....	1.30	1.15	2.10	2.20	1.45	.97	.52	1.90	
3	.....	1.32	1.30	2.08	2.35	1.19	.95	.50	1.25	
4	.....	1.31	1.05	2.01	3.10	1.45	.74	.65	1.18	
5	.....	1.25	.90	1.89	2.28	4.40	.83	.72	1.18	
6	.....	1.12	.90	1.62	2.10	2.85	.90	.74	1.00	
7	.....	1.02	.89	1.91	2.00	2.85	.90	.72	1.03	
8	.....	1.02	.90	2.10	2.58	2.20	.88	.79	1.04	
9	.....	1.10	.89	2.40	2.05	1.78	.76	.79	1.05	a
10	.....	1.05	.92	2.05	1.85	1.59	.70	.75	1.08	
11	.....	1.00	1.28	1.98	1.78	1.34	.72	.74	1.05	
12	.....	.99	1.35	2.15	1.65	1.20	.74	.65	1.09	
13	1.35	.95	1.43	2.20	1.48	1.11	.76	.68	1.12	
14	1.30	.95	1.63	2.20	3.40	2.25	.78	.80	1.14	
15	1.28	.95	1.81	2.50	3.30	2.25	.82	.89	1.16	
16	1.25	.....	1.79	2.60	3.20	1.48	.87	.88	1.03	
17	1.10	1.20	1.80	2.70	3.85	1.27	1.02	.85	1.00	
18	1.05	1.20	1.80	2.75	2.40	1.18	1.01	.86	.85	
19	1.00	1.22	1.91	2.65	3.00	1.10	1.12	.92	.75	
20	1.00	1.16	1.75	2.80	2.80	1.07	1.25	.94	.....	
21	.97	1.10	1.85	2.85	2.40	1.19	1.00	.95	1.20	
22	.93	1.16	2.05	2.85	2.15	1.17	1.00	.....	1.00	
23	.90	1.17	1.95	2.98	1.95	1.08	.98	.....	.98	
24	1.10	1.02	1.90	2.72	1.88	.95	1.00	1.00	1.00	
25	1.15	.90	1.80	2.68	2.01	.80	.94	1.00	.95	
26	.90	.90	1.95	2.50	1.48	.75	.90	1.01	.92	
27	.90	.95	2.02	2.30	1.25	.88	.80	1.02	.91	
28	1.27	.97	2.05	2.20	1.12	.88	.82	1.06	.91	
29	1.25	.95	2.08	2.05	3.20	.90	.84	1.09	.94	
30	1.20	1.10	1.90	1.92	2.45	.90	.72	1.13	.82	
31	1.38	.....	1.85	.....	2.92	.80	.....	1.10	.....	

a Readings discontinued December 9.

ARKANSAS RIVER AT LA JUNTA, COLORADO.

This station is situated at the head of the Fort Lyons canal, urements being taken of the water in the rating flume of the of that in its wasteway, and of that passing over the dam at th of the canal. The station is maintained by The Great Plains Company. On May 30, at gage height of 3.90 feet, the disch the canal was 772 second-feet, and 22 second-feet was in the way. October 17 the canal was carrying, at a gage height of 1.8 a discharge of 159 second-feet, with 44 second-feet in the was Continuous records of gage heights were not kept throughout th Three measurements of discharge were made by A. L. Fellows amount of water passing over the dam, for the purpose of sec rating table for the form of weir of which the Fort Lyons typical. The first, on May 30, at a gage height of 0.05 foot, discharge of 246 second-feet. The second, on June 13, with height of 0.47 foot, showed a discharge of 857 second-feet, a last measurement, on June 20, with a gage height of 0.67 foot, discharge of 1,181 second-feet.

PURGATORY RIVER AT TRINIDAD, COLORADO.

This stream is one of the principal tributaries entering the Arkansas iver from the south; it rises in northern New Mexico and flows in a eneral northeasterly direction across the plains, entering the main ream a short distance below Las Animas. The rod is attached to ie downstream side of the cylindrical pier of the Las Animas street ridge in the city of Trinidad, and has been maintained for a numer of years. Owing, however, to the unsatisfactory condition of the ver at this locality, the station was discontinued July 31, 1899. he results of measurements may be found as follows: 1896, Eighenth Annual Report, Part IV, page 232; 1897, Nineteenth Annual eport, Part IV, page 359; 1898, Twentieth Annual Report, Part IV, age 341. Two measurements of discharge were made in 1899 by . L. Fellows. The first one, on April 28, at a gage height of 3.60 et, gave a discharge of 52 second-feet; one on July 12, at a gage eight of 3.30 feet, showed a discharge of 4 second-feet.

Daily gage height, in feet, of Purgatory River at Trinidad, Colorado, for 1899.

ay.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.
1..	3.50	3.95	3.70	3.40	12...	3.50	3.80	3.60	3.85	23...	3.75	3.75	3.60	4.15
2..	3.50	3.85	3.70	3.75	13...	3.50	3.80	3.55	4.65	24...	3.80	3.60	3.70	3.65
3..	3.50	3.75	3.70	3.95	14...	3.55	3.80	3.50	4.80	25...	3.80	3.60	3.55	3.60
4.	3.50	3.70	3.70	3.75	15...	3.60	3.85	3.55	4.70	26 ..	3.85	3.60	3.40	3.50
5..	3.50	3.80	3.70	3.60	16...	3.70	4.00	4.20	4.15	27...	3.90	3.60	3.40	3.50
6..	3.50	3.70	3.55	3.50	17...	3.70	4.00	4.00	3.95	28...	3.90	3.60	3.30	4.75
7..	3.50	3.70	3.50	3.55	18...	3.80	3.90	3.90	4.25	29...	3.90	3.60	3.30	4.90
8..	3.50	3.65	3.50	3.70	19...	3.85	3.85	3.75	4.05	30...	3.95	3.60	3.30	4.20
9..	3.50	3.80	3.55	3.60	20...	3.90	3.90	3.60	3.85	31...	.....	3.70	.....	3.85
10..	3.50	3.80	3.60	3.50	21...	3.95	3.90	3.60	3.70					
11..	3.50	3.80	3.50	3.40	22...	3.75	3.95	3.55	3.60					

ARKANSAS RIVER AT AMITY CANAL HEAD GATES, COLORADO.

This station is located at the head of Amity canal, 7 miles west of amar, Colorado, and is maintained by the Amity Canal Company. ie observations here are not as satisfactory as they might be for termining the total flow of the river. The following measurements ere made by A. L. Fellows on the canal and wasteway: May 31, the nal, at a gage height of 2.63 feet, was discharging 249 second-feet, nile there were 129 second-feet in the wasteway; on June 18 the nount of water in the wasteway, at a gage height of 2.15 feet, was 4 second-feet. No measurements of the main river were made durg 1899.

The Arkansas River at the head of the Colorado and Kansas canal, miles west of Lamar, was measured September 8, 1899, and at a ge height of 0.20 feet on the dam was discharging 16 second-feet.

Daily gage height, in feet, of Arkansas River at Smith canal head gates, Colorado, for 1898.

Day.	Jan.	Feb.	Mar.	Apr.	May.	Day.	Jan.	Feb.	Mar.	Apr.	May.
1	1.50	1.40	2.40	2.30	0.40	17	1.40	2.40	4.30	1.50	2.10
2	1.50	1.40	2.40	1.90	.30	18	1.40	2.40	2.30	1.50	2.10
3	1.40	1.40	2.40	1.90	.30	19	1.40	2.40	2.30	1.50	2.10
4	1.40	1.40	2.40	1.80	.30	20	2.00	2.40	2.30	1.70	2.10
5	2.00	1.40	2.40	1.80	.30	21	2.20	2.40	2.20	1.60	2.10
6	2.00	1.40	2.30	1.70	1.30	22	2.00	2.40	2.10	1.60	2.10
7	2.00	1.40	4.40	1.90	.40	23	2.00	2.80	2.00	1.50	1.40
8	2.00	1.40	4.30	1.80	.30	24	2.40	2.80	2.00	1.50	1.30
9	2.00	1.40	4.40	1.90	.40	25	2.40	2.60	1.90	1.50	2.10
10	2.00	1.40	4.30	2.00	.30	26	2.40	2.60	2.00	.90	2.10
11	2.00	1.40	4.30	2.20	.30	27	2.40	2.60	1.80	.80	2.10
12	1.80	1.40	4.30	2.20	.30	28	2.70	2.60	2.50	.50	2.00
13	1.90	1.40	4.30	2.20	.30	29	2.40		2.30	.30	1.40
14	1.90	1.40	4.30	2.10	.40	30	2.50		2.40	.30	2.00
15	1.90	1.80	4.30	1.80	1.50	31	1.90		2.00		2.10
16	1.80	2.00	4.40	2.00	1.80						

ARKANSAS RIVER AT GRANADA, COLORADO.

This station was established July 24, 1898, and is located at the head gates of the Buffalo Creek canal, 2 miles northeast of Granada. There is an earth dam across the river at this point, with a footbridge over it, from which measurements were to have been attempted, but, owing to an occasional breaking of the dam during high stages of the river, none have been made since the station was established. The gage is vertical, well painted, and nailed to the head gates of the canal.

Daily gage height, in feet, of Arkansas River at Granada, Colorado, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.40	1.40	2.40	0.30	0.40	0.90	0.80	2.20	0.60	0.80	1.00	0.80
2	.40	1.40	2.40	.30	.60	.40	.90	1.80	.60	.80	1.20	.80
3	.50	1.40	2.40	.30	.80	.40	.80	1.00	.60	.80	3.00	.80
4	.40	1.60	2.40	.30	1.00	.80	.80	.80	.60	.80	2.00	.80
5	.40	1.60	2.40	.30	1.00	.60	3.00	1.40	.60	.80	1.00	1.00
6	.40	1.60	2.00	.30	1.00	.80	2.60	5.40	.60	.80	1.00	1.00
7	.40	1.60	1.60	.30	.80	.80	1.00	3.60	.60	.80	1.00	1.20
8	1.00	1.60	1.60	.30	.60	.80	.80	2.50	.70	.80	.80	1.20
9	1.00	1.60	1.40	.30	.60	1.00	.80	1.90	1.00	.80	.80	1.40
10	1.00	1.60	1.40	.30	.60	1.00	2.00	1.60	1.00	.80	.80	1.50
11	1.00	1.60	1.40	.30	.80	1.00	1.60	1.00	1.00	.80	.80	1.50
12	1.00	1.60	1.40	.30	.80	1.20	1.00	.60	.80	.80	.80	1.50
13	1.40	1.60	1.40	.20	.50	.80	2.00	.60	.60	.80	.80	2.00
14	1.40	1.80	1.40	.30	.50	.60	3.50	.60	.60	.80	.80	2.00
15	1.40	1.80	1.40	.80	.50	1.20	4.00	.60	.60	.80	.80	2.00
16	1.40	1.80	1.40	.80	.60	1.40	3.80	2.00	.60	.80	.80	2.50
17	1.40	1.80	1.40	.80	.60	1.00	4.00	1.50	.60	.80	.80	2.50
18	1.00	1.80	1.40	.60	.60	1.00	4.60	1.00	.60	.80	.80	2.50
19	1.00	2.00	.80	.60	.80	2.40	3.60	.80	.60	.80	.80	2.50
20	1.00	2.00	.60	.80	.80	.60	5.00	.80	.60	.80	.80	2.50
21	1.60	2.00	.60	.60	.60	.60	2.80	.80	.80	.80	.80	2.50
22	1.60	2.00	.60	.80	.60	1.20	2.00	.60	.80	.80	.80	2.50
23	1.80	2.00	.60	.60	.60	2.00	1.00	.60	.80	.80	2.20	3.00
24	1.40	2.00	.30	.60	.60	3.00	1.00	.60	.80	.80	1.10	3.00
25	1.40	2.40	.30	.40	.60	2.20	.80	.70	.80	.80	.80	3.00
26	1.40	2.40	.30	.60	.80	2.30	.80	.80	.80	.80	.80	3.00
27	1.40	2.40	.30	.60	.60	2.30	.80	.60	.80	.80	.80	3.00
28	1.60	2.40	.30	.60	.60	1.40	.80	.60	.80	.80	.80	3.00
29	1.60	.....	.50	.60	.80	1.00	3.00	.60	.80	.80	.80	3.00
30	1.80	.....	.50	.60	1.00	.80	1.60	.60	.80	.80	.80	3.00
31	1.40	.....	.40	.....	1.20	.....	2.80	.60	.....	.80	.....	3.60

ARKANSAS RIVER AT HUTCHINSON, KANSAS.

The Arkansas River, after crossing the Kansas and Colorado State line, is not systematically measured until Hutchinson, in about the center of the State, is reached. The station here was established May 13, 1895, and is located at the wagon bridge at the south end of Main street. The gage consists of an oak timber spiked to a pile a few feet above the bridge. Bench mark No. 1 is the upper crosspiece of the pier guard, with an elevation of 8.35 feet above zero of the gage. Bench mark No. 2 is the top of the iron doorsill of the first brick building next to the river, and its elevation is 8.12 feet above gage datum. The channel is straight for some distance above and below the bridge; the bed is sandy and very shifting. Results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 233; 1897, Nineteenth Annual Report, Part IV, page 361; 1898, Twentieth Annual Report, Part IV, page 343. Discharge measurements for 1899 were made by W. G. Russell, as follows:

May 2, gage height, 1.45 feet; discharge, 63 second-feet.
June 13, gage height, 3.95 feet; discharge, 2,790 second-feet.
June 14, gage height, 3.85 feet; discharge, 2,772 second-feet.
October 17, gage height, 1.20 feet; discharge, 30 second-feet.

Daily gage height, in feet, of Arkansas River at Hutchinson, Kansas, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	2.00	2.15	2.20	1.50	1.40	2.10	2.95	1.60	1.30	1.70	1.70
2	1.90	.....	2.50	2.20	1.55	1.35	2.10	2.80	1.50	1.20	1.70	1.70
3	1.95	.....	2.95	2.20	1.60	1.50	2.20	2.75	1.50	1.20	1.65	1.70
4	2.00	2.00	2.85	2.15	1.65	2.30	2.20	2.65	1.50	1.20	1.55	1.70
5	2.00	(a)	2.90	2.15	1.60	2.15	2.15	2.60	1.50	1.20	1.50	1.70
6	2.00	(a)	3.15	2.20	1.60	2.00	2.10	2.55	1.50	1.20	1.50	1.70
7	1.90	(a)	3.20	2.20	1.50	2.00	2.20	2.55	1.50	1.20	1.50	1.70
8	1.90	(a)	3.25	2.20	1.50	2.65	2.20	2.60	1.50	1.20	1.50	1.70
9	2.00	(a)	3.00	2.20	1.50	3.10	2.05	2.55	1.50	1.20	1.50	1.70
10	2.00	(a)	2.90	2.15	1.60	3.30	2.00	2.80	1.55	1.20	1.50	1.70
11	1.70	(a)	3.05	2.05	1.55	3.35	2.00	4.15	1.50	1.20	1.50	1.70
12	1.70	(a)	2.85	2.00	1.50	4.35	1.95	3.80	1.50	1.20	1.50	1.80
13	1.70	(a)	2.80	2.00	1.45	3.90	1.90	3.65	1.40	1.20	1.50	1.90
14	1.70	(a)	2.90	1.90	1.40	3.80	1.90	3.60	1.40	1.20	1.50	1.90
15	1.70	(a)	2.90	1.85	1.40	3.65	1.90	3.35	1.40	1.20	1.50	1.90
16	1.80	(a)	2.65	1.80	1.40	3.30	1.85	3.05	1.45	1.20	1.50	2.00
17	1.80	2.30	2.60	1.80	1.40	2.90	1.80	2.75	1.50	1.20	1.50	2.00
18	2.10	2.30	2.60	1.80	1.40	2.65	1.80	2.55	1.50	1.20	1.50	2.00
19	2.10	2.15	2.50	1.70	1.40	2.45	1.80	2.50	1.40	1.20	1.50	2.00
20	2.10	2.05	2.50	1.70	1.40	2.40	1.80	2.35	1.40	1.20	1.50	2.00
21	2.00	2.10	2.50	1.70	1.40	2.25	1.95	2.20	1.40	1.20	1.50	2.00
22	2.00	2.25	2.50	1.65	1.50	2.20	3.95	2.20	1.40	1.20	1.60	2.00
23	2.00	2.30	2.45	1.60	1.50	2.30	4.55	2.15	1.40	1.20	1.70	2.00
24	2.10	2.30	2.40	1.60	1.55	2.30	4.35	2.00	1.30	1.20	1.70	2.00
25	2.00	2.30	2.35	1.60	1.50	2.35	4.45	1.90	1.30	1.50	1.70	2.00
26	2.00	2.30	2.30	1.60	1.40	2.40	4.05	1.90	1.30	1.75	1.70	1.90
27	2.10	2.25	2.45	1.60	1.40	2.40	3.70	1.80	1.30	1.80	1.70	1.80
28	2.10	2.15	2.35	1.55	1.40	2.40	3.35	1.75	1.30	1.80	1.70	1.80
29	.....	.....	2.20	1.50	1.40	2.30	3.25	1.70	1.30	1.80	1.70	1.80
30	2.00	.....	2.20	1.50	1.40	2.15	3.20	1.65	1.30	1.80	1.70	1.80
31	.....	.....	2.25	.....	1.30	.....	3.20	1.60	.....	1.80	.....	1.80

a Frozen.

VERDIGRIS RIVER AT LIBERTY, KANSAS.

This river rises in the southeastern corner of Chase County, Kansas, and has a general southerly direction, passing out of the State near Coffeyville into Indian Territory. It enters Arkansas River 1 mile above the mouth of Grand, or Neosho, River near Fort Gibson.

It is essentially a surface run-off stream; its water is muddy, the fall flood large, the summer flow small, and the fluctuations in height rapid. There are a number of fine water powers located on the main stream and its various tributaries, and many of them were utilized several years ago. In the years 1880 to 1890 it is said that there were eleven dams on the Verdigris River, but at the present time not more than three or four are utilized. The drainage area is mapped on the Independence, Fredonia, Emporia, Eureka, Sedan, Eldorado, Cottonwood Falls, Parkerville, Newton, and Abilene atlas sheets. The station was established in August, 1895, and is located at a wagon bridge about 250 feet below McTaggart's mill dam, about 3 miles southwest of the town of Liberty, Kansas. The gage is a vertical timber fastened to the floor of the mill. Bench mark No. 1 is the heads of three large nails in the flume, and is at an elevation of 12.46 feet above the zero of the gage. Bench mark No. 2 is the head of a spike in the root of a cottonwood tree 40 feet south of the gage, and is at an elevation of 10.98 feet above gage datum. The bed is rocky, composed of gravel and subject to very little change. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 235; 1897, Nineteenth Annual Report, Part IV, page 369; 1898, Twentieth Annual Report, Part IV, page 344. The following discharge measurements were made by E. C. Murphy and W. G. Russell during 1899:

May 19, gage height, 3.03 feet; discharge, 311 second-feet.
June 10, gage height, 21.30 feet; discharge, 16,906 second-feet.
July 6, gage height, 21.50 feet; discharge, 16,505 second-feet.
October 11, gage height, 1.70 feet; discharge, 17 second-feet.

Daily gage height, in feet, of Verdigris River at Liberty, Kansas, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.80	2.80	4.10	4.10	3.65	6.75	2.80	4.50	2.00	1.70	1.90	1.90
2	3.70	2.70	3.80	4.10	3.75	5.15	2.80	4.20	2.00	1.70	1.90	1.90
3	3.20	2.70	3.60	3.80	4.05	3.70	2.75	3.60	2.00	1.70	1.90	1.90
4	3.00	2.70	3.50	3.60	7.35	5.55	12.40	3.15	2.00	1.70	1.90	1.90
5	3.30	2.70	3.50	3.40	6.75	6.35	15.40	3.05	2.00	1.70	1.90	1.90
6	3.30	2.70	3.40	3.60	4.70	8.60	15.95	2.80	2.00	1.70	1.90	1.90
7	3.20	2.70	3.30	3.80	4.85	9.35	8.55	2.75	2.00	1.70	1.80	1.90
8	3.20	2.60	3.20	4.10	5.05	5.80	26.90	2.60	2.00	1.70	1.80	1.90
9	3.20	2.60	3.10	4.00	4.65	10.35	30.45	2.60	2.00	1.70	1.80	1.90
10	3.10	2.60	3.20	3.80	4.45	21.45	19.75	2.50	2.00	1.70	1.80	1.90
11	3.10	2.60	3.20	3.70	4.15	24.05	8.75	2.50	2.00	1.70	1.80	1.90
12	3.10	2.60	7.10	3.60	4.00	24.75	4.90	2.50	2.00	1.70	1.80	2.00
13	3.30	2.50	6.30	3.50	3.85	19.10	4.55	2.40	2.00	1.70	1.80	2.00
14	3.20	2.50	6.00	4.30	3.65	9.15	4.25	2.75	2.00	1.70	1.80	2.00
15	3.10	2.50	5.60	3.70	3.45	5.75	4.20	5.55	2.00	1.70	1.80	2.00
16	3.20	2.50	5.90	3.30	3.20	7.50	4.25	3.40	2.00	1.70	1.80	2.00
17	3.10	2.40	5.00	3.30	3.20	5.65	6.40	2.90	2.00	1.70	1.80	2.00
18	3.20	2.40	4.80	3.70	3.00	4.80	7.65	2.65	2.00	1.70	1.80	2.00
19	3.10	2.40	4.90	3.85	3.00	4.40	7.05	2.45	1.90	1.70	1.80	2.00
20	3.00	2.40	5.80	7.15	6.60	4.05	7.20	2.40	1.90	1.60	1.90	1.90
21	3.00	3.10	4.80	6.45	10.20	3.85	7.65	2.30	1.90	1.60	1.90	1.90
22	3.00	3.20	4.60	8.45	5.10	3.60	7.70	2.30	1.90	1.60	1.90	1.90
23	2.90	3.10	4.10	11.20	6.70	3.40	6.40	2.30	1.90	1.60	1.90	2.00
24	2.90	3.00	3.90	6.50	14.65	3.25	4.75	2.20	1.90	1.60	1.90	2.00
25	2.90	3.10	3.80	5.30	9.65	3.20	4.10	2.20	1.90	1.60	1.90	2.00
26	3.00	6.60	3.70	4.70	4.80	3.35	3.85	2.20	1.80	1.90	1.90	2.00
27	3.00	6.00	3.50	4.45	4.40	3.20	3.65	2.10	1.80	2.00	1.90	2.00
28	3.00	4.50	3.50	4.25	4.00	3.05	3.45	2.10	1.80	2.00	1.90	2.10
29	3.00	.....	3.40	4.35	4.00	3.00	3.15	2.00	1.70	2.00	1.90	2.10
30	3.00	.....	3.70	3.80	3.70	2.85	3.10	2.00	1.70	2.00	1.90	2.10
31	2.90	.....	4.10	.....	3.45	.....	3.85	2.00	.....	2.00	.....	2.10

NEOSHO RIVER AT IOLA, KANSAS.

This river drains a long, narrow strip in southeastern Kansas, xtending into Indian Territory. The upper part of the basin has general east-west direction, draining the area immediately south f Kansas River and north of the headwaters of Verdigris River. he general direction of the river bends gradually southward between mporia and Iola, and that direction is maintained for the rest of s course. Neosho River in Indian Territory is known as Grand iver. During the last season two gaging stations were maintained ı the basin—one at Iola, the other at Fort Gibson, near the mouth. he former station was established in July, 1895, and is located at the ighway bridge 1 mile west of the city of Iola, Kansas. The gage is astened to the head gates of the flume about 90 feet above the bridge. he bench mark is the heads of three large nails driven into the cross-iece of the flume, and is 13.30 feet above the datum of the gage. tesults of measurements may be found as follows: 1896, Eighteenth ınnual Report, Part IV, page 238; 1897, Nineteenth Annual Report, 'art IV, page 362; 1898, Twentieth Annual Report, Part IV, page 46. The following discharge measurements were made by E. C. Murhy and W. G. Russell during 1899:

May 18, gage height, 2.70 feet; discharge, 242 second-feet.
June 9, gage height, 18 feet; discharge, 27,959 second-feet.
July 5, gage height, 8.20 feet; discharge, 6,313 second-feet.
July 8, gage height, 16.70 feet; discharge, 25,849 second-feet.
October 11, gage height, 2.30 feet; discharge, 316 second-feet.

Daily gage height, in feet, of Neosho River at Iola, Kansas, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.00	2.70	3.60	3.85	3.10	4.50	2.80	2.80	2.70	2.30	2.00	2.00
2	2.90	2.60	3.55	3.70	3.10	5.20	2.80	2.70	2.70	2.30	2.00	2.00
3	2.90	2.60	3.60	3.70	3.00	4.45	3.00	2.70	2.60	2.30	2.00	2.00
4	2.80	2.60	3.60	4.20	3.10	4.80	12.50	2.70	2.60	2.30	2.00	2.00
5	2.80	2.60	3.65	4.40	3.10	6.30	8.90	2.60	2.60	2.30	2.00	2.00
6	2.80	2.60	3.70	4.00	3.00	7.95	5.80	2.50	2.50	2.30	2.00	2.00
7	2.80	2.60	3.70	3.85	3.10	6.60	14.00	2.60	2.50	2.30	2.00	2.00
8	2.70	2.60	3.60	3.60	3.10	5.55	16.50	3.05	2.45	2.30	2.00	2.00
9	2.70	2.60	3.50	3.60	3.10	17.03	9.80	2.90	2.40	2.25	2.00	2.00
10	2.80	2.50	3.50	3.50	3.15	15.70	6.60	2.80	2.40	2.20	2.00	2.00
11	2.80	2.50	4.90	3.50	3.30	11.40	4.50	2.70	2.40	2.20	2.00	2.00
12	2.80	2.50	11.05	3.40	3.50	11.50	3.75	2.60	2.40	2.20	2.00	2.10
13	2.90	2.50	6.05	3.40	3.40	9.20	3.25	2.50	2.40	2.20	2.00	2.10
14	2.90	2.60	5.45	3.40	3.40	5.60	3.00	2.50	2.40	2.20	2.00	2.10
15	2.90	2.70	5.00	3.40	3.25	4.75	3.65	2.50	2.40	2.20	2.00	2.10
16	2.90	2.80	4.50	3.30	3.00	4.40	4.65	2.55	2.40	2.20	2.00	2.10
17	2.90	2.90	4.85	3.20	2.90	4.20	4.80	3.30	2.40	2.10	2.00	2.20
18	2.90	2.95	7.55	3.20	2.85	4.10	4.10	3.00	2.40	2.10	2.00	2.20
19	2.80	3.10	5.85	3.10	2.85	4.05	3.60	2.80	2.40	2.10	2.00	2.20
20	2.80	3.15	5.40	4.50	2.90	3.85	3.95	2.80	2.40	2.10	2.00	2.20
21	2.80	3.20	5.15	4.05	2.90	3.70	5.35	2.60	2.40	2.10	2.00	2.20
22	2.80	3.30	4.65	3.80	2.90	3.60	6.40	2.60	2.40	2.10	2.00	2.20
23	2.80	3.40	4.10	3.75	4.65	3.50	3.50	2.60	2.40	2.10	2.00	2.10
24	2.80	3.60	3.85	3.60	6.60	3.25	3.35	2.50	2.40	2.10	2.00	2.10
25	2.80	3.95	3.65	3.50	4.90	3.15	3.05	2.50	2.40	2.00	2.00	2.10
26	2.80	5.95	3.55	3.40	6.95	3.10	3.00	2.60	2.40	2.00	2.00	2.10
27	2.80	4.70	3.70	3.30	6.55	3.05	2.85	2.60	2.40	2.00	2.00	2.10
28	2.70	3.90	3.90	3.20	4.45	3.00	2.80	2.60	2.40	2.00	2.00	2.10
29	2.70	.....	4.20	3.10	3.85	2.90	2.70	2.85	2.40	2.00	2.00	2.10
30	2.70	.....	4.20	3.10	3.70	2.80	2.70	2.85	2.40	2.00	2.00	2.10
31	2.70	.....	3.95	.....	3.25	.....	2.70	2.75	.....	2.00	.....	2.10

GRAND RIVER AT FORT GIBSON, INDIAN TERRITORY.

In its lower course through Indian Territory Neosho River is known as Grand River. The station was established by W. G. Russell, May 16, 1899, at the railroad bridge one-half mile north of the station at Fort Gibson and 3 miles above the mouth of the river. The rod is spiked to the ties of the bridge. The initial point for soundings is the left end of the bridge. The channel is straight for some distance both above and below the station. The right bank is liable to overflow, while the left is not, being high and rocky. The bed of the stream is sandy and shifting at the right side and toward the center. W. Blackwell, railroad pump man, is the observer. Two measurements of discharge were made here by W. G. Russell during 1899. The first one was on May 16, at a gage height of 15.00 feet, and showed a discharge of 19,823 second-feet; the second measurement was on October 12, with a gage height of 9.20 feet, and gave a discharge of 1,070 second-feet.

Daily gage height, in feet, of Grand River at Fort Gibson, Indian Territory, for 1899.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	13.80	12.80	15.20	10.90	10.00	10.00	11.90
2	.....	13.80	13.00	15.00	10.90	10.00	10.00	11.80
3	.....	13.80	13.00	14.80	10.40	10.00	10.00	11.60
4	.....	14.70	13.20	14.90	10.20	10.00	10.00	11.40
5	.....	13.60	13.70	14.40	10.20	10.00	10.00	11.10
6	.....	13.00	14.00	14.20	10.10	10.00	10.00	11.00
7	.....	12.90	14.60	14.00	10.00	10.00	10.00	10.80
8	.....	16.20	14.70	13.90	10.00	9.90	10.00	10.50
9	.....	16.00	14.80	13.70	10.00	9.90	10.00	10.40
10	.....	16.30	14.90	13.30	10.00	9.80	10.00	10.40
11	.....	15.20	15.00	13.20	10.00	9.70	10.00	10.20
12	.....	17.20	15.40	13.00	10.00	9.20	10.00	10.00
13	.....	19.00	15.90	13.00	10.00	9.20	10.00	10.00
14	.....	19.80	16.00	12.90	10.00	9.10	10.00	10.00
15	.....	19.60	16.80	12.90	10.00	9.10	10.00	10.00
16	15.00	17.60	17.00	12.80	10.00	9.10	10.00	10.00
17	15.00	16.60	17.60	12.70	9.90	9.00	10.00	10.00
18	13.60	15.60	17.90	12.60	9.80	9.00	10.00	10.00
19	13.50	14.50	17.90	12.60	9.70	9.00	10.20	10.00
20	13.40	14.00	17.60	12.40	9.70	9.00	10.40	10.00
21	13.30	14.00	17.40	12.20	9.70	9.00	10.60	10.00
22	14.30	14.00	17.40	12.10	9.60	9.10	11.00	10.00
23	14.70	13.80	17.00	12.00	9.60	9.10	11.20	10.00
24	15.60	13.80	17.00	12.00	9.70	9.10	11.50	10.00
25	15.10	13.10	16.80	11.90	9.80	9.20	11.80	10.10
26	14.80	13.00	16.60	11.80	9.80	9.20	12.00	10.20
27	14.80	13.00	16.00	11.80	9.80	9.50	12.00	10.30
28	14.80	13.00	16.00	11.60	9.90	9.50	12.00	10.40
29	14.80	13.00	15.80	11.40	9.90	9.60	12.00	10.40
30	13.80	13.00	15.60	11.20	9.90	9.70	11.90	10.50
31	13.80	.....	15.40	11.00	.....	9.80	.....	10.60

NORTH FORK OF CANADIAN RIVER AT OKLAHOMA, OKLAHOMA.

This stream rises in the extreme northeast corner of the panhandle of Texas. Its general course across Oklahoma and Indian Territory is southeasterly, emptying into the main Canadian River 45 miles above its mouth. The basin is a long, narrow area located between *Cimarron* River on the north and the main Canadian River on the

Two gaging stations are maintained on the river, one at ›ma, Oklahoma, and the other at Eufaula, Indian Territory. ›rmer station was established by W. G. Russell May 19, 1899, located at the highway bridge, east of the Atchison, Topeka ›nta Fe Railroad bridge, one-half mile south of the town. The ›ank is high, but the left is low and liable to overflow. H. E. a farmer living near by, is the observer. Two measurements ›harge were made by W. G. Russell during 1899, as follows: ›st, on May 19, at a gage height of 5.50 feet, gave a discharge of ›ond-feet; the second, on October 15, at a gage height of 2.80 ›owed a discharge of 22 second-feet.

›ge height, in feet, of North Fork of Canadian River at Oklahoma, Oklahoma, for 1899.

›y.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	.....	6.10	5.10	9.30	3.30	3.10	3.40	5.50
.....	.....	5.90	5.00	8.60	3.20	3.10	3.30	5.50
.....	.....	5.70	4.90	8.00	3.30	3.00	3.10	5.40
.....	.....	5.60	4.80	7.60	3.20	3.00	3.10	5.30
.....	.....	6.20	4.70	7.10	3.20	2.90	3.30	5.20
.....	.....	6.50	4.60	6.90	3.20	2.90	3.50	5.10
.....	.....	6.20	4.50	6.20	3.20	2.90	3.60	5.00
.....	.....	6.90	4.50	5.90	3.20	2.90	3.60	4.10
.....	.....	6.20	4.30	5.60	3.10	2.90	3.70	5.20
.....	.....	5.90	4.30	5.40	3.30	2.90	3.70	5.10
.....	.....	6 50	4.50	5.30	3.20	2.90	3.70	4.90
.....	.....	8.00	5.00	5.20	3.10	2.80	3.80	4.80
.....	.....	9.30	5.20	5.00	3.10	2 80	3.90	4.70
.....	.....	7.80	5.10	4.90	3.00	2.80	4.00	4.60
.....	.....	8.00	4.60	4.80	3.00	2.80	4.20	4.50
.....	.....	11.10	4.50	4.70	3.00	2.80	4.60	4.40
.....	.....	11.00	4.40	4.60	3.00	2.80	5.00	4.40
.....	.....	9.40	6.00	4.40	3.10	2.80	5.20	4.40
.....	5.50	8.80	4.50	4.30	3.00	2.70	6.00	4.30
.....	5.40	8.00	4.30	4.30	3.00	2.70	12.10	4.30
.....	5.30	7.80	4.30	4.20	3.00	2.70	13.60	4.60
.....	5.20	7.20	5.00	4.10	3.00	2.70	13.50	4.60
.....	5.20	7.00	4.80	4.00	3.00	2.60	12.60	4.50
.....	5.10	6.80	6.00	3.11	3.60	2.60	7.90	4.40
.....	5.60	6.50	6.30	3.10	3.60	2.90	6.00	4.30
.....	5.70	6.10	7.50	3.90	3.50	3.00	5.90	4.30
.....	6.40	5.90	7.60	3.80	3.40	3.50	5.80	4.20
.....	6.40	5.70	8.50	3.70	3.30	4.00	5.70	4.20
.....	6.20	5.50	9.00	3.60	3.30	3.00	5.60	4.10
.....	5.80	5.30	10.20	3.50	3.30	4.00	5.60	4.10
.....	6.20	.....	10.30	3.40	.....	3.70	.....	4.20

FORK OF CANADIAN RIVER AT EUFAULA, INDIAN TERRITORY.

› station was established by W. G. Russell May 17, 1899, and is l at the railroad bridge of the Missouri, Kansas and Texas ad, 5 miles above the mouth of the river and 2 miles north of vn of Eufaula. The channel is straight for some distance both and below the station. The right bank is high, but the left s low and liable to overflow. The bed of the stream is sandy ›ifting. H. Erwin, railroad pump man, is the observer. Two rements of discharge were made during 1899 by W. G. Russell: ›st, on May 17, with a gage height of 24.00 feet, gave a discharge)72 second-feet; the second, on October 13, with a gage height) feet, gave a discharge of 154 second-feet.

Daily gage height, in feet, of North Fork of Canadian River at Eufaula, Indian Territory, for 1899.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	12.00	11.60	12.00	10.50	10.00	10.00	11.50
2	.....	12.00	11.60	11.60	10.50	9.80	9.80	11.50
3	.....	11.60	11.50	11.60	10.50	9.80	9.70	11.50
4	.....	11.60	11.00	11.50	10.50	9.60	9.50	11.50
5	.....	11.60	11.00	12.00	10.30	9.50	9.50	11.50
6	.....	10.00	10.60	12.00	10.40	9.50	9.50	11.50
7	.....	10.50	10.50	12.00	10.40	9.50	9.50	11.50
8	.....	11.50	10.60	12.00	10.30	9.50	9.40	11.50
9	.....	11.60	10.60	11.60	10.00	9.50	9.40	11.50
10	.....	12.00	10.60	11.60	10.00	9.50	9.40	11.50
11	.....	14.00	11.00	11.50	10.00	9.50	9.30	11.50
12	.....	14.00	11.00	11.50	10.00	9.50	9.40	11.50
13	.....	13.00	12.00	11.50	10.00	9.50	9.40	11.40
14	.....	11.00	12.50	11.50	10.00	9.50	9.40	11.40
15	.....	12.00	12.50	11.50	10.00	9.50	9.30	10.40
16	.....	13.00	11.50	11.40	10.00	9.40	9.20	10.40
17	24.00	14.00	11.00	11.00	10.00	9.40	9.20	10.30
18	23.60	15.00	10.60	11.00	10.00	9.50	9.20	10.50
19	23.00	17.00	11.00	11.00	10.00	9.50	9.20	11.00
20	22.50	20.00	12.60	11.00	10.00	9.40	9.20	11.00
21	21.30	20.00	13.00	11.00	10.00	9.40	9.50	11.00
22	20.50	19.00	13.00	11.00	10.00	9.30	9.60	11.40
23	19.90	16.00	14.00	10.80	10.00	9.20	10.50	11.50
24	20.50	13.00	16.00	10.80	10.00	9.20	10.70	11.50
25	19.60	12.50	18.00	10.80	10.00	9.30	12.00	11.50
26	18.60	12.00	11.50	10.80	10.00	9.30	12.50	11.50
27	18.00	11.50	11.00	10.80	10.00	9.60	12.50	11.30
28	17.60	11.50	11.00	10.70	10.00	10.20	12.50	11.00
29	15.00	11.00	12.00	10.70	10.00	10.00	12.30	10.00
30	12.50	11.50	12.00	10.60	10.00	10.00	12.30	10.00
31	12.00	.....	12.00	10.60	.....	10.00	.....	9.60

WASHITA RIVER AT PAULS VALLEY, INDIAN TERRITORY.

This river rises in the eastern edge of the Texas Panhandle, immediately south of Canadian River. Its general direction is southeasterly through Oklahoma Territory, and then into Indian Territory, emptying into Red River about 11 miles above the crossing of the Missouri, Kansas and Texas Railroad. The gaging station was established by W. G. Russell on May 20, 1899, and is located at the highway bridge, 2 miles east of the town of Pauls Valley, Indian Territory. The channel is straight for some distance above and below the station; the right bank is low and liable to overflow, but the left bank is high. The bed of the stream is sandy and shifting. Two measurements of discharge were made at this point by W. G. Russell in 1899: The first, on May 20, with a gage height of 8.50 feet, gave a discharge of 684 second-feet; the second, made on October 15, at a gage height of 4.60 feet, gave a discharge of 96 second-feet.

e height, in feet, of Washita River at Pauls Valley, Indian Territory, for 1899.

	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	.....	7.60	7.30	12.80	5.40	5.10	6.00	8.50
.....	.....	6.80	7.20	9.90	5.40	5.00	5.80	8.00
.....	.....	6.50	7.00	8.90	5.30	4.90	5.50	7.80
.....	.....	6.50	7.00	8.20	5.10	4.80	5.40	7.60
.....	.....	6.20	7.00	7.80	5.00	4.80	5.30	7.50
.....	.....	6.40	6.90	7.70	5.00	4.70	5.20	7.40
.....	.....	7.30	6.80	7.70	5.00	4.70	5.10	7.00
.....	.....	8.80	8.30	7.60	4.90	4.70	5.00	6.80
.....	.....	7.70	9.50	7.20	5.90	4.70	4.90	7.00
.....	.....	7.50	8.50	7.00	4.90	4.70	4.80	7.40
.....	.....	9.40	7.70	7.80	4.90	4.70	4.80	7.40
.....	.....	8.80	7.00	6.80	4.90	4.70	4.80	7.50
.....	.....	9.00	6.90	6.70	4.90	4.60	4.80	7.50
.....	.....	9.50	9.00	6.60	4.90	4.50	4.80	7.50
.....	.....	10.70	9.10	6.50	4.90	4.60	4.70	8.60
.....	.....	11.50	8.50	6.30	4.90	4.60	4.70	8.00
.....	.....	12.70	8.00	6.10	5.00	4.60	4.80	7.40
.....	.....	16.20	7.50	6.00	5.20	4.60	7.00	7.50
.....	.....	15.70	8.90	6.00	5.70	4.50	14.55	7.20
.....	8.50	13.70	8.00	5.90	5.50	4.50	20.70	7.00
.....	7.90	12.20	7.50	5.80	5.40	4.50	20.70	6.80
.....	7.80	11.40	8.90	5.70	5.20	4.50	19.80	6.50
.....	7.40	10.50	9.00	5.70	5.20	4.50	19.05	6.60
.....	7.40	9.10	9.50	5.80	5.00	4.50	15.75	6.50
.....	7.20	8.20	9.30	5.70	6.00	4.70	14.25	6.40
.....	7.00	8.00	9.40	5.70	5.70	5.00	15.60	6.30
.....	6.90	7.80	8.30	5.50	5.50	6.00	16.50	6.60
.....	6.80	7.30	7.80	5.50	5.30	7.50	13.90	6.50
.....	6.80	7.50	9.80	5.50	5.30	6.50	11.30	6.50
.....	7.00	7.80	12.70	5.40	5.20	6.40	9.00	6.40
.....	7.70	.....	14.00	5.40	.....	6.30	.....	6.00

TRINITY RIVER AT DALLAS, TEXAS.

iver rises in Montague and Cooke counties, in northern ne headwater streams draining the area within a few miles of 'er on the north. The general course of Trinity River is terly, and it empties into the Gulf of Mexico at Galveston. re basin is located in Texas. The station, established Octo- 98, is located at Turtle Creek pump house, 3 miles north of ɣ-house in Dallas. The height of the water is indicated by : which slides up and down in the well of the pump house. l is connected with the river by a pipe. Measurements of dis- re made by wading. The channel is practically straight above w the point of measurement. The right bank is high, the left r and liable to overflow. The bed of the stream is of gravel ting. There was no discharge of the river from June 22 to 30. Three discharge measurements were made during 1899 nas U. Taylor, as follows: The first one, on June 20, at a ght of 57 feet, gave a discharge of 269 second-feet; June 22, neight of 53.30 feet gave a discharge of 0 second-feet; the easurement was on December 29, at a gage height of 56.60 l gave a discharge of 336 second-feet.

Daily gage height, in feet, of Trinity River at Dallas, Texas, for 18

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	55.50	55.25	55.50	54.20	57.45	55.50	64.60	56.20	52.65	50.35	60.25
2	55.40	54.90	55.85	54.20	56.85	55.40	63.25	55.75	52.25	50.35	60.45
3	55.40	54.55	55.80	54.20	56.60	55.30	58.60	55.45	51.80	50.00	60.55
4	55.40	54.40	55.45	54.20	56.30	55.20	59.05	55.20	51.40	50.25	58.80
5	55.30	54.60	55.45	54.30	55.85	55.20	63.20	55.20	51.05	49.95	57.30
6	55.25	54.95	55.00	54.80	55.70	55.15	73.35	54.95	50.25	50.30	56.05
7	55.15	54.85	54.40	54.65	57.10	55.00	69.60	54.80	51.15	50.20	55.70
8	55.30	54.65	54.65	54.50	57.50	55.00	59.45	54.80	51.05	50.25	55.55
9	55.65	54.65	54.45	54.50	58.75	54.95	57.25	54.75	50.80	50.25	55.40
10	55.55	54.80	53.95	54.50	61.10	55.60	56.75	54.65	49.80	50.30	55.30
11	55.75	54.40	53.90	54.70	59.00	56.45	56.55	54.55	51.05	50.35	55.15
12	55.65	54.25	53.90	54.95	59.75	61.70	56.30	54.75	51.20	50.30	54.95
13	56.30	54.45	54.10	55.00	58.05	62.55	56.20	54.60	51.15	49.75	54.95
14	59.10	54.55	54.55	54.65	57.55	58.75	56.45	54.50	51.00	50.25	54.95
15	58.15	54.95	54.35	54.95	57.70	57.95	56.05	54.40	51.15	50.30	54.95
16	57.50	54.45	54.10	55.80	57.70	57.65	55.70	54.35	50.95	50.30	55.00
17	56.85	54.80	54.00	56.70	57.75	59.65	55.40	54.35	51.35	50.05	54.60
18	56.45	54.55	54.65	57.10	58.00	61.10	55.30	54.40	51.40	50.00	54.25
19	56.05	54.90	54.40	56.60	57.80	58.25	55.45	54.20	50.35	50.00	54.05
20	55.70	54.45	54.00	56.30	56.95	57.20	55.80	53.75	50.65	50.00	58.20
21	55.55	54.30	53.95	55.90	56.80	58.20	55.30	53.40	51.30	49.90	67.30
22	55.45	54.75	54.25	55.65	56.80	58.40	58.25	53.05	51.30	49.80	71.05
23	55.50	54.40	54.10	55.50	56.80	58.55	57.50	52.75	51.40	49.80	65.45
24	55.55	54.05	54.05	55.55	57.00	58.60	57.30	52.40	51.10	49.80	62.75
25	55.40	54.50	54.15	55.60	57.95	57.90	56.65	52.00	50.38	49.80	64.20
26	55.15	54.40	54.20	57.30	58.00	56.95	56.20	51.55	49.80	49.80	68.10
27	55.00	54.20	54.25	58.30	58.00	56.40	55.80	51.85	50.25	49.80	71.90
28	55.20	54.05	54.45	58.55	57.60	56.00	57.10	52.00	50.15	49.95	74.55
29	55.30	.....	54.30	58.55	56.85	55.90	56.45	52.15	50.00	50.15	76.00
30	55.25	.....	54.25	58.00	55.85	59.20	55.85	52.35	50.10	53.10	74.45
31	55.30	.....	54.20	.....	55.65	.....	56.10	52.50	.....	50.30	.....

BRAZOS RIVER AT WACO, TEXAS.

This river has its source in the Staked Plains region of Texas, and has a general southeasterly course, emptying i Gulf of Mexico south of the mouth of Trinity River. Its d basin is entirely within the State of Texas. The gaging s established by T. U. Taylor September 14, 1898, is located Austin street bridge, northwest of Waco. The gage is inclin channel straight, and the banks high. The bed of the strea shifting sand. Measurements of discharge have been made the suspension bridge above the railroad bridge. Under the at low water, is a sand bar, which does not, however, aff reliability of the measurements, as there are then two distinc nels. Three measurements of discharge were made in 1899 by T U. Taylor: The first, on June 19, at a gage height of 18.50 feet, sh discharge of 58,700 second-feet; the measurement of June gage height of 6.90 feet, gave a discharge of 4,430 second-feet the third measurement, on December 30, at a gage height of 4. showed a discharge of 2,085 second-feet.

Daily gage height, in feet, of Brazos River at Waco, Texas, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.70	2.30	2.20	1.80	2.10	6.00	a15.00	5.30	2.45	1.10	7.10	5.30
2	2.65	2.35	2.25	1.90	2.05	5.45	17.00	5.00	2.40	1.10	6.65	4.90
3	2.60	2.40	2.20	1.90	2.00	4.75	12.45	4.90	2.30	1.10	6.10	4.45
4	2.50	2.40	2.20	1.90	2.40	4.25	11.25	4.70	2.40	2.00	5.65	4.20
5	2.50	2.40	2.15	1.90	2.70	4.00	14.85	4.20	2.30	2.00	5.30	4.05
6	2.50	2.35	2.10	2.20	2.70	3.70	12.60	3.95	2.30	2.00	5.00	3.95
7	2.60	2.40	2.10	2.10	2.60	3.85	12.20	3.75	2.30	2.00	4.75	3.85
8	2.50	2.25	2.00	2.10	2.60	7.40	10.10	3.60	2.30	1.90	4.35	3.85
9	2.50	2.25	2.20	2.10	2.55	10.30	9.00	3.60	2.20	1.90	4.10	3.95
10	2.50	2.40	2.05	2.10	3.15	9.45	8.40	3.50	2.20	1.95	3.85	4.25
11	2.50	2.40	2.00	2.05	5.10	7.95	8.35	3.40	2.15	1.95	3.70	6.45
12	2.50	2.30	1.95	1.95	5.25	7.40	7.50	3.30	2.10	1.90	3.60	9.75
13	2.50	2.30	1.90	1.80	5.75	7.10	6.95	3.20	2.10	1.90	3.50	8.60
14	2.50	2.30	2.00	1.90	4.70	6.60	6.50	3.15	2.10	1.90	3.40	7.55
15	2.60	2.30	2.00	5.90	4.05	6.30	6.25	3.10	2.10	1.90	3.30	6.70
16	2.45	2.30	2.00	2.75	4.20	6.60	5.90	3.00	2.05	1.90	3.20	6.00
17	2.40	2.40	2.00	2.55	4.30	10.00	5.70	3.00	2.10	1.90	3.15	5.80
18	2.40	2.40	2.00	2.60	6.20	6.55	5.65	2.95	2.15	1.90	3.10	5.70
19	2.45	2.40	2.10	2.45	5.55	18.50	5.40	2.90	2.10	1.90	3.30	5.15
20	2.50	2.35	1.95	2.40	4.80	20.70	5.20	2.80	2.10	1.90	5.90	4.95
21	2.50	2.30	1.90	2.35	4.20	18.05	5.15	2.80	2.30	1.90	19.85	5.85
22	2.55	2.30	1.90	2.30	4.10	10.25	5.00	2.70	2.65	1.90	21.85	9.40
23	2.40	2.30	1.80	2.30	3.75	9.10	5.30	2.70	2.45	1.90	11.85	6.55
24	2.50	2.30	1.90	2.20	4.50	8.20	9.95	2.70	2.40	1.90	8.90	6.20
25	2.50	2.30	1.80	2.20	6.40	7.35	9.00	2.60	2.30	1.95	8.40	6.10
26	2.40	2.30	1.90	2.15	5.85	6.85	8.30	2.55	2.40	2.25	7.25	5.75
27	2.40	2.30	1.90	2.20	5.45	6.30	7.25	2.50	2.40	2.55	6.70	5.50
28	2.40	2.20	1.90	2.20	5.05	6.10	6.60	2.50	2.35	2.50	6.20	5.05
29	2.35	.....	1.85	2.10	5.00	a9.00	6.10	2.50	2.20	9.15	5.60	4.95
30	2.40	.....	1.80	2.05	7.25	a12.00	5.90	2.50	.....	11.00	5.45	4.85
31	2.30	.....	1.80	.....	6.50	.....	5.70	2.50	.....	8.30	.....	4.70

a Estimated.

BRAZOS RIVER AT LEWIS, TEXAS.

This station, established by Thomas U. Taylor February 22, 1898, at the International and Great Northern Railroad bridge about 1¼ miles southwest of the town of Lewis, Texas, and about 75 miles below the station at Waco. After the establishment of the Waco station the one at Lewis was not of much importance, and was discontinued February 25, 1899. No measurements of discharge were made here during 1899.

Daily gage height, in feet, of Brazos River at Lewis, Texas, for 1899.

Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.	Day.	Jan.	Feb.
1	4.40	4.30	9	4.50	4.20	17	4.00	4.20	25	4.30	4.20
2	4.40	4.25	10	4.60	4.20	18	4.45	4.20	26	4.25	.....
3	4.35	4.20	11	4.80	4.20	19	4.40	4.20	27	4.20	.....
4	4.30	4.20	12	5.15	4.20	20	4.40	4.20	28	4.15	.....
5	4.40	4.20	13	5.45	4.20	21	4.40	4.20	29	4.05	.....
6	4.70	4.10	14	6.25	4.20	22	4.35	4.20	30	4.15	.....
7	4.55	4.15	15	5.10	4.20	23	4.25	4.20	31	4.20	.....
8	4.50	4.20	16	4.85	4.20	24	4.20	4.20			

Station discontinued February 25.

COLORADO RIVER AT AUSTIN, TEXAS.

This river drains a large area in central Texas. It rises in the extreme western portion of the State, within a few miles of the western boundary of New Mexico, and flows in a general southeasterly direction, emptying into the Gulf of Mexico in Matagorda County. Its head-water tributaries drain the country immediately south of the Brazos River. Llano Creek is a tributary of Colorado River and empties into it 85 miles above Austin. On March 14, 1899, this stream was measured one-half mile west of the station at Llano, Texas, and showed a discharge of 76 second-feet; a second measurement was made below on this creek, 200 yards above its junction with the Colorado River at Kingsland, on the same date, which also showed a discharge of 76 second-feet. On March 13 the main Colorado River, at a short distance below the wagon bridge near Marble Falls, Texas, showed a discharge of 197 second-feet. The river was also measured four times at the head of Lake McDonald, about 20 miles above Austin. On January 31 it showed a discharge of 210 second-feet; on October 3 the discharge was 134 second-feet; on October 4 the discharge was also 134 second-feet; and on the same date, at another section near by, the discharge was 136 second-feet. On March 15 two measurements were made at the power house at the Austin dam. The first measurement was in the fore bay, and showed a discharge of 206 second-feet; immediately afterwards the tailrace was measured and showed a discharge of 233 second-feet. The station maintained during 1899 is located at the Congress avenue bridge, south of the city of Austin. The gage rod is a vertical timber attached to a bath house near by. The bench mark is on the first flange above the cribwork of the north pier of the highway bridge, and is 4.78 feet above the zero of the gage. The following measurements of discharge were made by Thomas U. Taylor during 1899:

March 17, gage height, 1.70 feet; discharge, 267 second-feet.
March 31, gage height, 1.50 feet; discharge, 170 second-feet.
November 10, gage height, 1.71 feet; discharge, 476 second-feet.
November 16, gage height, 1.50 feet; discharge, 386 second-feet.
November 28, gage height, 2.36 feet; discharge, 1,156 second-feet.
December 5, gage height, 2.02 feet; discharge, 686 second-feet.

Daily gage height, in feet, of Colorado River at Austin, Texas, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.90	2.00	1.85	1.45	2.05	3.60	3.85	3.10	1.45	1.05	2.80	2.65
2	1.85	1.95	1.85	1.45	2.05	3.20	3.35	2.45	1.45	1.05	2.35	2.50
3	1.85	1.90	1.75	1.45	2.00	2.95	3.55	2.30	1.45	.90	2.10	2.50
4	1.95	2.05	1.85	1.45	2.10	3.55	3.50	1.95	1.45	.85	2.10	2.20
5	1.95	1.95	1.85	1.55	2.00	3.15	3.65	1.80	1.45	.90	1.95	2.05
6	1.95	1.90	1.85	1.50	2.05	2.85	3.45	1.70	1.40	.90	1.95	2.05
7	1.85	1.90	1.90	1.50	1.95	11.35	3.15	1.75	1.40	.85	2.00	2.05
8	1.95	1.85	1.80	1.45	1.85	21.05	2.95	1.75	1.40	.80	1.90	2.40
9	1.95	1.90	1.85	1.45	1.95	17.60	3.60	1.65	1.40	.85	1.80	2.75
10	1.95	1.90	1.80	1.45	2.00	14.75	3.25	1.65	1.35	.90	1.75	3.45
11	1.95	1.90	1.75	1.45	2.00	9.00	3.00	1.65	1.35	.90	1.70	6.40
12	2.05	2.10	1.75	1.45	4.10	5.30	2.80	1.55	1.35	.90	1.65	5.35
13	1.95	1.95	1.75	1.50	7.95	4.45	2.65	1.55	1.35	.90	1.60	4.30
14	1.90	1.80	1.75	1.55	7.10	4.10	2.50	1.55	1.35	.90	1.65	3.70
15	1.85	1.75	1.80	1.50	5.30	3.60	2.30	1.55	1.35	.90	1.60	3.35
16	1.90	1.80	1.80	1.50	4.55	3.75	2.15	1.55	1.35	.90	1.55	3.05
17	1.90	1.85	1.75	1.55	3.85	4.40	2.05	1.55	1.35	.85	1.50	2.85
18	1.95	1.80	1.75	1.65	3.40	5.90	2.00	1.55	1.35	.95	1.45	2.70
19	1.95	1.75	1.75	1.80	3.20	6.60	2.00	1.55	1.30	1.45	1.75	2.60
20	1.90	1.75	1.70	1.90	3.00	6.15	2.00	1.65	1.30	.95	2.00	2.65
21	1.90	1.75	1.65	3.95	2.75	4.90	1.90	1.55	1.25	.90	5.35	2.75
22	1.90	1.75	1.65	3.80	2.45	6.00	1.85	1.55	1.25	.90	6.35	2.90
23	1.90	1.85	1.60	3.45	4.20	5.15	1.80	1.55	1.15	.90	4.55	4.05
24	1.90	1.90	1.60	3.05	4.05	4.15	1.80	1.55	1.15	1.40	5.65	3.90
25	1.95	1.85	1.60	2.85	4.75	3.75	1.75	1.55	1.10	1.35	3.00	3.40
26	1.90	1.85	1.60	2.65	4.50	3.45	2.35	1.55	1.15	1.45	2.65	3.05
27	1.90	1.85	1.60	2.55	5.05	3.15	2.45	1.55	1.15	1.55	2.55	2.85
28	1.90	1.75	1.60	2.45	4.85	2.95	2.20	1.55	1.15	2.30	2.35	2.75
29	1.90	.....	1.55	2.35	4.10	2.85	3.30	1.55	1.15	3.35	2.35	2.70
30	1.90	.....	1.45	2.25	3.70	2.75	4.25	1.55	1.05	2.90	2.95	2.55
31	1.95	.....	1.50	.....	3.35	.....	3.60	1.55	.....	3.10	.....	.....

GUADALUPE RIVER AT NEW BRAUNFELS, TEXAS.

This river drains a small area in central Texas. Its source is in err County, and it has a general southeasterly direction, emptying ito the Gulf of Mexico in Calhoun County. At New Braunfels it eceives Comal River, which is the principal source of supply for the pper Guadalupe. Comal River is simply the outlet of a series of arge springs near New Braunfels and is only about 3 miles long. 'hese springs maintain a very constant flow throughout the entire 'ear. Comal River is described in Bulletin 140, page 84. The gaging tation at New Braunfels is about 1 mile east of the town, near the highway bridge, and below the International and Great Northern Raiload bridge, and was established March 13, 1898. It is located below he mouth of Comal River, and hence includes the flood waters of the nain Guadalupe besides the very equable discharge of Comal River. 'wo measurements of discharge were made by Thomas U. Taylor uring 1899: The first, on March 16, with a gage height of 1.80, howed a total discharge of the two channels of 358 second-feet; the econd one, on December 23, with a gage height of 2.70 feet, gave a ischarge of 797 second-feet.

Daily gage height, in feet, of Guadalupe River at New Braunfels, Texas, for 1898.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.80	1.80	1.80	1.80	1.80	1.90	3.65	2.00	1.80	1.70	2.40	2.00
2	1.80	1.80	1.80	1.80	1.80	1.90	2.65	2.00	1.80	1.70	2.30	2.00
3	1.80	1.80	1.80	1.80	1.80	1.85	2.45	1.90	1.80	1.70	2.05	2.00
4	1.80	1.80	1.80	1.80	2.15	1.80	2.35	1.90	1.80	1.70	2.00	1.90
5	1.80	1.80	1.80	1.85	2.05	1.80	2.60	1.90	1.80	1.70	2.00	1.90
6	1.80	1.80	1.80	1.90	1.85	3.85	2.60	1.90	1.80	1.70	2.00	1.90
7	1.80	1.80	1.80	1.80	1.80	3.25	2.50	1.90	1.80	1.70	1.90	1.95
8	1.80	1.80	1.80	1.80	1.80	16.00	2.45	1.90	1.80	1.70	1.90	2.65
9	1.80	1.80	1.80	1.80	1.80	8.00	2.30	1.85	1.80	1.70	1.90	2.60
10	1.80	1.80	1.80	1.80	1.80	4.20	2.30	1.80	1.80	1.70	1.90	2.30
11	1.80	1.80	1.80	1.80	2.65	3.55	2.25	1.80	1.80	1.70	1.90	2.20
12	1.80	1.80	1.80	1.80	2.10	3.10	2.20	1.80	1.80	1.70	1.90	2.20
13	1.80	1.80	1.80	1.80	1.95	3.45	2.10	1.80	1.80	1.70	1.60	2.10
14	1.80	1.80	1.80	1.80	1.90	3.00	2.10	1.80	1.80	1.70	1.90	2.10
15	1.80	1.80	1.80	1.85	1.90	2.75	2.10	1.80	1.80	1.70	1.90	2.00
16	1.80	1.80	1.80	1.85	1.90	2.55	2.10	1.80	1.80	1.70	1.90	2.00
17	1.80	1.80	1.80	1.80	1.90	4.45	2.00	1.80	1.80	1.70	1.80	2.00
18	1.80	1.80	1.80	1.80	1.90	3.05	2.00	1.80	1.80	1.70	1.80	2.10
19	1.80	1.80	1.80	1.80	1.80	3.15	2.00	1.80	1.80	1.70	1.90	2.25
20	1.80	1.80	1.80	1.95	1.80	2.85	1.90	1.80	1.80	1.70	2.15	2.40
21	1.80	1.80	1.80	2.45	1.80	2.60	1.90	1.80	1.80	1.90	2.10	2.65
22	1.80	1.80	1.80	2.20	1.80	2.50	1.90	1.80	1.80	2.00	2.10	2.80
23	1.80	1.80	1.80	2.00	4.20	2.45	1.90	1.80	1.80	2.00	2.30	2.70
24	1.80	1.80	1.80	2.00	2.90	2.40	1.90	1.80	1.80	2.00	2.30	2.55
25	1.80	1.80	1.80	2.00	2.50	2.40	2.00	1.80	1.80	2.00	2.30	2.40
26	1.80	1.80	1.80	2.00	2.30	2.30	2.00	1.80	1.75	2.00	2.10	2.30
27	1.80	1.80	1.80	1.90	2.05	2.20	2.00	1.80	1.70	2.15	2.10	2.30
28	1.80	1.80	1.80	1.80	2.00	2.20	4.50	1.80	1.70	6.15	2.00	2.20
29	1.80	.....	1.80	1.80	2.00	2.15	3.35	1.80	1.70	3.30	2.00	2.20
30	1.80	.....	1.80	1.80	2.00	2.10	2.20	1.80	1.70	2.70	2.00	2.20
31	1.80	.....	1.80	.....	1.90	.....	2.00	1.80	.....	2.45	.....	.....

LEONA RIVER AT UVALDE, TEXAS.

In former years there was located in the southern suburbs of Uvalde a large spring with constant flow, known as "Leona spring." This spring was dry but once between 1870 and 1893, viz, in 1885. It soon revived, however, and continued flowing up to 1893, when the discharge stopped, and no water has issued from it since that date. The water in the wells in the vicinity in 1884 was 25 feet below the surface of the ground, but in 1899 the level was about 50 feet below the surface. A pumping station was located on the banks of Leona River, near Leona spring, in 1893, but after one or two years the river failed to such an extent that the entire pumping plant was moved to within 150 yards of the court-house at Uvalde. At the new station a 15 by 15 foot pit was excavated 24 feet deep, and the pumps were placed at the bottom of this pit, and then a well 4 by 7 feet square was sunk from this level to a depth of 16 feet, out of which the water was pumped into a standpipe. The water at first rose in this well to within 35 feet of the ground surface. In December, 1897, it was noticed that the supply was failing, and this continued until May, 1898, when a second pit, 10 by 10 feet, and 9 feet deep, was excavated on the southwest side of the first pit, and the well was also lowered until its bottom was 63 feet below the ground surface; when the pumps were finally lowered, their new position was 33 feet below the surface. In January, 1899, it was found necessary to sink three small drill wells in the bottom of the main pump well to a depth of

10 to 35 feet, reaching a total depth of 98 feet from the surface of the ground.

Leona River, in 1895, was found by Mr. Cyrus C. Babb to be dry under the railroad bridge, but at the crossing 1½ miles south of the town a discharge of 11 second-feet was found. The river ceased flowing at this crossing in January, 1898. About June 15, 1899, heavy rains fell over Uvalde and Kinney counties, raising the Leona River to a flowing depth of 6 to 8 feet. Notwithstanding this, on June 28, 1899, when visited by Thomas U. Taylor, the river was dry at the crossing above referred to. The bed of the stream was followed to the head of the upper irrigation ditch about 4 miles below the town of Uvalde, but no flowing water was found. The only irrigation along Leona River in 1899 was done through the agency of a steam pump 10 or 12 miles below Uvalde.

LAS MORAS SPRING, NEAR BRACKETTVILLE, TEXAS.

This spring is located at Fort Clark, near Brackettville, 10 miles distant from Spofford, on the Southern Pacific Railroad. The discharge from this spring was measured by Prof. Thomas U. Taylor on June 30, 1899, when 60 second-feet was found. A measurement on December 24, 1895, near the same point, by Cyrus C. Babb, showed a discharge of 21 second-feet.

SAN FELIPE SPRINGS, NEAR DEL RIO, TEXAS.

San Felipe Creek has its source in four large springs, the upper one being 2 miles above the railroad bridge near Del Rio, the others being within about 200 yards of the bridge. On June 29, 1899, the creek was measured by Prof. Thomas U. Taylor, at a point about 200 yards below the railroad bridge, and a discharge of 84 second-feet was found. Madre ditch diverts water from one of these springs above the point of measurement, and on June 29 its discharge was found to be 29 second-feet. Previous measurements at this locality will be found in Bulletin 140, page 85.

RIO GRANDE AT DEL NORTE, COLORADO.

This river has its source in the Continental Divide in southern Colorado. Its general course is easterly through its mountainous collecting area until San Luis Park is reached, when it gradually takes a southeasterly course, and then just before crossing the State line into New Mexico it bends southward and continues this general course throughout New Mexico. The station is located about 2 miles above the town of Del Norte, Colorado, well above most of the irrigation ditches which divert water from this river. The gage consists of an inclined 2 by 6 inch plank fastened to a post driven into the right bank of the river. Bench mark No. 1 is a large nail in the root of a tree 15 feet northeast of the end of the cable on the left bank of the

river and is 7.54 feet above gage datum. Bench mark No. 2 is a large nail in the root of a tree 25 feet northwest of the end of the inclined gage, and is also 7.54 feet above gage datum. While the banks are not high, the river has never been known to overflow. The current is swift; the bed is composed of small stone, and has not materially changed during the last year. Discharge measurements are made from a box suspended from a five-eighths inch wire cable fastened to trees on each side of the river. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 247; 1897, Nineteenth Annual Report, Part IV, page 383; 1898, Twentieth Annual Report, Part IV, page 360. The following discharge measurements were made by A. L. Fellows during 1899:

April 25, gage height, 2.42 feet; discharge, 1,004 second-feet.
May 24, gage height, 2.92 feet; discharge, 1,480 second-feet.
June 29, gage height, 2.10 feet; discharge, 734 second-feet.
August 21, gage height, 1.58 feet; discharge, 387 second-feet.

Daily gage height, in feet, of Rio Grande at Del Norte, Colorado, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1				1.62	1.90	2.94	2.00	2.24	1.46			
2												1.96
3				1.48	1.82	2.62	2.12	2.20	1.50			
4		2.64	2.82								1.64	
5				1.40	1.86	2.44	1.98	2.64	1.48			
6												
7	2.76			1.40	1.96	2.50	2.12	2.42	1.40	1.50		
8												
9				1.52	2.16	2.68	1.94	2.12	1.40			2.00
10												
11		2.60	2.66	1.70	3.62	2.82	1.90	2.00	1.40		1.60	
12												
13				1.84	3.54	2.90	1.80	1.84	1.38			
14	2.74									1.90		
15				1.92	3.20	2.62	1.86	1.76	2.12			
16												2.30
17				2.04	3.18	2.50	1.86	1.82	1.86			
18		2.46	2.04								1.62	
19				2.10	3.14	2.38	2.74	1.70	1.64			
20												
21	2.68			2.14	3.02	2.32	2.14	1.60	1.58	1.80		
22												
23				2.30	2.84	2.20	2.02	1.60	1.52			2.04
24												
25		2.48	1.96	2.46	3.04	2.10	1.84	1.54	1.48		2.04	
26												
27				2.28	2.96	2.48	1.84	1.50	1.44			
28	2.84									1.72		
29				2.24	2.84	2.10	2.00	1.48	1.42			
30									1.42			2.12
31			1.64		2.90		2.24	1.42				

CONEJOS RIVER AT LOS MOGOTES, COLORADO.

This stream rises on the eastern slope of the mountain range which forms the western line of Conejos County, in southern Colorado. It flows southeasterly, and then bending at the town of Conejos flows in a general northeasterly direction, entering the Rio Grande below the mouth of Trinchera Creek. The gage rod, established by A. L. Fellows August 25, 1899, was at first located at a wagon bridge 10 miles above the town of Conejos, but owing to the fact that it was destroyed

his point, it was later moved to a point about 500 yards below. It ere attached to the pier projecting into the river near the house upied by Gustav Timm, a ranchman who has acted as observer. channel is fairly good, being of gravel and not particularly liable ither change or overflow. Owing to the removal of the gage it will be possible to make a rating table for 1899. Two measurements lischarge were made at this point in 1899 by A. L. Fellows: The t, on August 25, at a gage height of 1.00 foot, showed a discharge 76 second-feet; the second measurement, on November 28, at a gage ght of 2.20 feet, showed a discharge of 70 second-feet.

ily gage height, in feet, of Conejos River at Los Mogotes, Colorado, for 1899.

ay.	Sept.	Oct.	Nov.	Day.	Sept.	Oct.	Nov.	Day.	Sept.	Oct.	Nov.
1	.95	1.02	1.15	12	.98	1.20	1.57	23	1.18	1.30	1.50
2	.92	1.05	1.12	13	.95	1.38	1.57	24	1.15	1.28	1.48
3	.92	1.10	1.12	14	.98	1.32	1.57	25	1.10	1.25	1.40
4	.92	1.12	1.10	15	2.00	1.25	1.57	26	1.05	1.25	1.55
5	.90	1.10	a 1.55	16	1.75	1.22	1.65	27	1.05	1.15	1.90
6	.90	1.07	1.57	17	1.65	1.25	1.70	28	1.05	1.20	2.20
7	.87	1.07	1.57	18	1.50	1.28	1.70	29	1.05	1.18	2.10
8	.87	1.05	1.57	19	1.30	1.25	1.70	30	1.05	1.15	1.00
9	1.02	1.05	1.57	20	1.22	1.20	1.60	31	.....	1.15	.....
0	1.05	1.02	1.57	21	1.22	1.30	1.58				
1	1.00	1.00	1.57	22	1.20	1.32	1.55				

a Gage moved to a point near house of Gustav Timm.

RIO GRANDE AT CENICERO, COLORADO.

The Rio Grande for a number of years has been dry during the mmer after passing through San Luis Park, due to the diversion water above. On August 20 the river 6 miles below Alamosa, Colo-lo, was carrying 17 second-feet, and on the 23d of the same month, a point one-half mile above Alamosa, the discharge was found to 10 second-feet. Just before it crosses the State line into New xico it enters the canyon, and in order to obtain the amount of ter passing out of the State, a station was located on June 28, 1899, A. L. Fellows, at the State bridge across the Rio Grande, at a int about 4 miles west of Eastdale, Colorado. The station is vorably located for the purpose, the cross section being fairly uni-rm, the channel regular and not liable to overflow. The gage con-ts of two rods, one for low stages, fastened to a rock near the shore; e upper section is fastened to the lower side of the middle pier of e bridge. The observer is Roman Mondragon. The following asurements of discharge were made by A. L. Fellows in 1899:

June 28, gage height, 0.90 foot; discharge, 20 second-feet.
August 24, gage height, 1 foot; discharge, 31 second-feet.
November 28, gage height, 1.80 feet; discharge, 297 second-feet.

Daily gage height, in feet, of Rio Grande at Cenicero, Colorado, for 1899.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.78	1.00	1.00	1.30	1.50	1.80
2	.....	.90	1.00	1.00	1.30	1.50	1.80
3	.....	.88	.90	1.00	1.20	1.60	1.80
4	.....	.90	.90	1.00	1.40	1.60	1.70
5	.....	1.00	1.40	1.00	1.30	1.60	1.60
6	.....	.90	1.40	1.00	1.20	1.60	1.50
7	.....	.90	1.30	1.00	1.20	1.60	1.60
8	.....	.90	1.40	1.00	1.20	1.70	1.60
9	.....	.90	1.40	1.00	1.30	1.70	1.70
10	.....	.85	1.30	1.00	1.30	1.80	1.60
11	.....	.80	1.30	1.00	1.40	1.70	1.60
12	.....	.80	1.30	1.00	1.30	1.70	1.70
13	.....	.85	1.30	1.10	1.30	1.70	1.70
14	.....	.90	1.20	1.10	1.20	1.80	1.80
15	.....	1.00	1.10	1.60	1.30	1.80	1.90
16	.....	1.00	1.00	2.10	1.30	1.70	2.00
17	.....	1.00	1.00	2.00	1.40	1.70	2.00
18	.....	.98	1.00	1.40	1.40	1.70	2.00
19	.....	1.00	1.00	1.50	1.40	1.70	2.00
20	.....	1.00	.90	1.50	1.40	1.70	2.00
21	.....	1.02	.90	1.50	1.40	1.70	2.00
22	.....	1.08	1.00	1.40	1.40	1.80	2.00
23	.....	1.50	1.00	1.40	1.40	1.80	2.00
24	.....	1.50	1.00	1.40	1.40	1.80	2.00
25	.....	1.35	.95	1.30	1.50	1.80	2.00
26	.....	1.30	.90	1.30	1.50	1.80	2.00
27	.....	1.20	.90	1.30	1.50	1.80	2.00
28	0.90	1.10	1.00	1.30	1.50	1.80	2.00
29	.90	1.10	1.00	1.30	1.50	1.80	2.00
30	.80	1.10	1.00	1.30	1.50	1.80	2.00
31	.....	1.00	1.00	.....	1.50	.....	2.00

RIO GRANDE AT EMBUDO, NEW MEXICO.

Rio Grande enters the canyon some distance above where it crosses the New Mexico and Colorado line, and continues southward for some distance below Embudo. It receives a number of important tributaries from either side through this section of its course, which contribute to its discharge; and although in recent years the river is dry in the vicinity of Alamosa, Colorado, there is a constant flow at Embudo, New Mexico. The station at this point, established in 1889, is located about 300 feet east of the railroad station at Embudo. The gage is inclined, and consists of a timber fastened to posts driven into the bank of the river. Bench mark No. 1 is a rock near the end of the cable, left bank, marked "B. M." with white paint, and is 20.66 feet above gage datum. Bench mark No. 2 is a rock 100 feet above the cable, left bank, similarly marked, and is 18.79 feet above gage datum. Bench mark No. 3 is a notch cut in the southeastern corner of the station, 2 feet above the platform, and is 30.48 feet above gage datum. The left bank is steep, and the right has a gentle slope. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 251; 1897, Nineteenth Annual Report, Part IV, page 385; 1889 to 1898, Twentieth Annual Report, Part IV, page 366. The following measurements of discharge were made by P. E. Harroun during 1899:

April 7, gage height, 8.20 feet; discharge, 710 second-feet.
April 20, gage height, 9.50 feet; discharge, 1,627 second-feet.
May 4, gage height, 8.60 feet; discharge, 967 second-feet.
May 30, gage height, 8.10 feet; discharge, 745 second-feet.
September 4, gage height, 7 feet; discharge, 183 second-feet.
October 27, gage height, 7.58 feet; discharge, 412 second-feet.

Daily gage height, in feet, of Rio Grande at Embudo, New Mexico, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.50	7.60	7.70	8.40	9.20	7.90	7.20	7.20	7.00	7.30	7.60	7.85
2	7.60	7.60	7.70	8.30	9.00	7.85	7.20	7.25	7.00	7.30	7.60	7.85
3	7.60	7.60	7.80	8.30	8.80	7.80	7.15	7.20	7.00	7.35	7.60	7.80
4	7.60	7.70	7.80	8.30	8.60	7.80	7.10	7.20	7.00	7.40	7.60	7.80
5	7.60	7.70	7.85	8.20	8.45	7.80	7.10	7.30	7.00	7.40	7.65	8.00
6	7.70	7.70	7.90	8.20	8.25	7.00	7.10	7.25	7.00	7.40	7.70	7.85
7	7.85	7.70	8.00	8.20	8.20	7.35	7.10	7.20	7.00	7.40	7.75	7.70
8	7.90	7.80	8.05	8.10	8.20	7.00	7.10	7.20	7.10	7.40	7.80	7.70
9	7.90	7.80	8.15	8.10	8.20	6.90	7.10	7.20	7.10	7.40	7.80	7.80
10	7.90	7.85	8.20	8.10	8.20	6.85	7.10	7.30	7.10	7.40	7.80	8.00
11	7.90	7.90	8.20	8.10	8.20	6.70	7.05	7.25	7.10	7.40	7.80	7.60
12	7.90	7.80	8.25	8.20	8.30	6.60	7.00	7.20	7.10	7.40	7.80	7.60
13	7.90	7.90	8.30	8.50	8.65	6.70	7.00	7.20	7.15	7.40	7.80	7.60
14	7.80	7.80	8.35	8.65	8.80	6.95	7.10	7.20	7.20	7.40	7.80	7.70
15	7.80	7.80	8.50	8.80	9.00	7.00	7.25	7.25	a 7.30	7.50	7.85	7.60
16	7.70	7.80	8.65	8.80	9.10	7.00	7.40	7.30	8.15	7.50	7.90	7.60
17	7.70	7.80	8.70	8.85	9.20	7.00	7.60	7.30	7.90	7.50	7.90	7.70
18	7.70	7.70	8.70	9.05	9.20	7.00	7.60	7.15	7.85	7.50	7.90	7.70
19	7.70	7.70	8.70	9.35	9.15	7.00	8.10	7.10	7.80	7.50	7.90	7.70
20	7.70	7.70	8.65	9.35	9.00	7.00	7.90	7.10	7.65	7.50	7.90	7.70
21	7.70	7.70	8.60	9.30	9.00	7.00	7.60	7.10	7.60	7.50	7.95	7.70
22	7.70	7.70	8.45	9.25	8.80	7.00	7.60	7.10	7.50	7.50	8.00	7.70
23	7.70	7.70	8.40	9.20	8.75	7.00	7.55	7.00	7.50	7.50	8.00	7.70
24	7.70	7.70	8.30	9.20	8.50	7.10	7.50	7.00	7.50	7.50	8.00	7.70
25	7.60	7.70	8.30	9.30	8.20	7.10	7.45	7.00	7.40	7.50	8.10	7.70
26	7.60	7.70	8.30	9.40	8.20	7.10	7.35	7.00	7.40	7.50	8.10	7.70
27	7.60	7.70	8.30	9.40	8.10	7.00	7.20	7.00	7.30	7.50	8.00	7.70
28	7.60	7.70	8.35	9.30	8.10	7.15	7.15	7.00	7.30	7.50	8.00	7.70
29	7.60	.....	8.40	9.20	8.10	7.20	7.10	7.00	7.30	7.60	7.90	7.70
30	7.60	.....	8.35	9.20	8.00	7.20	7.10	7.00	7.30	7.60	7.90	7.70
31	7.60	.....	8.40	.....	8.00	.....	7.20	7.00	.....	7.60	.....	7.70

a Began to rise at 4.30 p. m.; maximum, 8.3 feet, at 6 p. m.

RIO GRANDE AT RIO GRANDE, NEW MEXICO.

Three miles below Embudo the river emerges into Espanola Valley, through which it continues for a few miles and then enters White Rock Canyon, flowing through that canyon for 30 miles. At the lower end of this canyon the river emerges into Albuquerque Valley, and so continues down to about Socorro. This valley averages from 1 to 3 miles in width, and has been irrigated for a great many years by the Mexican settlers. Their primitive methods of irrigation are very wasteful of the waters, so that the duty of water in this section, about 17 acres per second-foot, is not as high as it might be. During the last few years, however, a number of important and modern irrigation systems have been planned and built in the vicinity of Albuquerque. The gaging station, established February 3, 1895, is located about one-fourth of a mile above the railroad station of Rio Grande, New Mexico, and at the head of White Rock Canyon. The gage is inclined, and consists of timbers fastened to piles and wired to a solid rock. The bench mark is the top of the bowlder to which the upper portion of the gage is fastened, and is 17.815 feet above gage datum. Measurements are made from a car suspended from a cable above the rod. The bed of the stream is rocky and is confined between high banks. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 254; 1897, Nineteenth Annual Report, Part IV, page 386; 1898,

Twentieth Annual Report, Part IV, page 370. Three measurements of discharge were made at this point by P. E. Harroun during 1899: The first one, on April 6, at a gage height of 5.90 feet, gave a discharge of 978 second-feet; the second, on September 2, at a gage height of 3.70 feet, gave a discharge of 110 second-feet; the third measurement, October 24, at a gage height of 5.15 feet, gave a discharge of 482 second-feet.

Daily gage height, in feet, of Rio Grande at Rio Grande, New Mexico, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.65	5.40	5.65	6.20	7.15	5.60	4.20	5.00	3.60	4.70	5.30	5.65
2	4.65	5.35	6.00	6.20	7.15	5.55	4.20	4.80	3.60	4.70	5.25	5.60
3	4.65	5.35	5.90	6.05	6.95	5.45	4.30	4.70	3.60	4.70	5.30	5.60
4	4.75	5.15	5.80	6.15	6.75	5.45	4.30	6.75	3.65	4.85	5.40	5.60
5	4.85	5.30	5.80	6.10	6.60	5.45	4.10	5.50	3.60	5.10	5.40	5.35
6	4.75	5.20	5.85	5.90	6.50	5.35	4.00	5.00	3.60	5.05	5.45	5.00
7	4.85	5.30	5.85	5.85	6.45	5.25	4.00	6.35	3.55	5.05	5.50	5.25
8	4.95	5.30	5.90	6.05	6.35	5.20	3.90	5.45	4.00	5.00	5.55	5.40
9	5.10	5.45	6.15	5.95	6.35	5.05	4.40	5.45	4.25	4.95	5.55	5.65
10	5.00	5.45	6.05	6.05	6.30	5.40	4.20	4.80	4.75	4.90	5.55	5.45
11	4.95	5.45	6.25	6.30	6.30	5.10	4.20	4.75	4.95	4.85	5.60	5.25
12	5.00	5.35	6.25	6.45	6.45	5.05	4.20	4.65	4.35	4.85	5.55	5.15
13	4.95	5.20	6.20	6.65	6.40	5.00	4.00	4.60	4.30	4.85	5.55	5.40
14	5.00	5.75	6.20	6.95	6.65	4.90	4.40	4.55	4.30	4.80	5.55	5.40
15	5.05	5.50	6.25	7.30	7.15	4.85	4.55	4.40	a9.30	4.80	5.90	5.15
16	5.05	5.40	5.85	7.20	7.35	4.60	5.00	4.35	9.40	5.00	5.70	4.85
17	5.00	5.50	6.15	7.65	7.40	4.65	5.05	4.30	6.55	5.00	5.75	5.10
18	5.00	5.45	6.40	8.15	7.15	4.50	7.80	4.15	5.85	5.05	5.70	5.40
19	5.00	5.50	6.30	8.30	6.90	4.45	6.80	4.20	5.45	4.95	5.70	5.65
20	5.05	5.45	6.35	8.30	6.75	4.40	6.30	4.15	5.25	5.05	5.70	5.55
21	5.05	5.50	6.30	7.95	6.75	4.30	5.70	4.10	5.15	5.10	5.70	5.40
22	5.00	5.50	6.25	7.70	6.75	4.20	5.30	4.00	5.25	5.15	5.70	5.30
23	5.00	5.50	6.20	7.75	6.40	4.20	5.30	3.90	5.00	5.15	5.80	5.45
24	5.00	5.55	6.15	7.85	6.25	4.30	5.15	3.75	5.05	5.15	5.80	5.50
25	5.05	5.80	6.20	7.90	6.10	4.40	5.25	3.85	4.95	5.20	5.80	5.45
26	5.10	5.50	6.45	8.05	6.10	4.65	5.20	3.80	4.85	5.20	5.75	5.45
27	5.20	5.50	6.65	7.95	5.95	4.50	5.30	3.70	4.85	5.30	5.75	5.40
28	5.25	5.65	6.60	7.75	6.00	4.40	5.35	3.75	4.75	5.30	5.75	5.40
29	5.25	.....	6.55	7.50	5.85	4.20	5.00	3.70	4.75	5.30	5.70	5.45
30	5.35	.....	6.45	7.15	5.80	4.35	5.05	3.60	4.65	5.25	5.70	5.50
31	5.40	.....	6.40	.....	5.70	.....	6.05	3.60	.....	5.25	.....	5.65

a 10 at 7 a. m.

RIO GRANDE AT SAN MARCIAL, NEW MEXICO.

The fifth gaging station on the main stream, continuing downward, is at San Marcial. It was established January 29, 1895, and is located at the railroad bridge one-half mile south of the town. The wire gage is attached to the guard rail of the bridge, south span, lower side. Bench mark No. 1 is the top of the capstone on which the bridge truss rests, and is at an elevation of 15 feet above gage datum; bench mark No. 2 is the top of the extension of the pier to which the old vertical gage was fastened, and is at an elevation of 13 feet above gage datum. The channel is sandy and shifting. A number of bridge piers interfere with the current to a certain extent, but not with the observed gage heights or discharge measurements. Results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 257; 1897, Nineteenth Annual Report, Part IV, page 387; 1898, Twentieth Annual Report, Part IV, page 371. The following discharge measurements were made by P. E. Harroun during 1899:

Measurements of Rio Grande at San Marcial, New Mexico.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec. feet.*	1899.	*Feet.*	*Sec. feet.*
Apr. 3	7.30	715	May 17	6.50	199
Apr. 19	7.30	660	Sept. 22	5.30	112
Apr. 25	7.70	1,609	Oct. 12	4.40	6
May 2	7.60	1,403	Dec. 17	6.20	263

Daily gage height, in feet, of Rio Grande at San Marcial, New Mexico, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.95	6.90	6.70	7.00	7.70	6.00	.....	6.00	.....	.....	5.00	6.50
2	6.75	6.65	6.70	7.15	7.65	5.80	.....	5.80	.....	.....	5.00	6.50
3	6.50	6.70	6.60	7.30	7.50	5.70	.....	5.60	.....	.....	5.10	6.50
4	6.60	6.70	6.50	7.10	7.40	5.60	.....	5.40	.....	.....	5.10	6.55
5	6.55	6.60	6.50	7.00	7.40	5.40	.....	5.65	.....	.....	5.20	6.55
6	6.60	6.50	6.70	6.90	7.30	5.25	.....	6.80	.....	.....	5.20	6.55
7	6.60	5.10	6.70	7.20	7.20	5.00	.....	7.15	.....	.....	5.30	6.55
8	6.75	4.50	6.50	7.00	7.20	.....	.....	7.55	.....	.....	5.30	6.60
9	6.55	4.50	6.80	6.90	7.20	.....	.....	6.95	5.35	.....	5.40	6.60
10	6.50	6.95	6.50	6.80	7.10	.....	.....	6.40	5.65	.....	5.40	6.45
11	6.60	6.60	6.50	6.70	7.00	.....	.....	6.10	5.00	.....	5.50	6.60
12	7.00	6.70	6.50	6.50	6.80	.....	.....	5.70	5.15	.....	5.50	6.55
13	6.70	5.90	6.60	6.40	6.70	.....	.....	5.30	5.50	4.50	5.60	6.55
14	7.00	7.20	7.00	6.30	6.60	.....	.....	.....	5.05	4.50	5.60	6.55
15	6.90	6.70	7.10	6.15	6.50	.....	3.00	.....	.....	4.50	5.70	6.60
16	6.85	6.70	7.00	6.00	6.40	.....	3.60	.....	.....	4.50	5.70	6.60
17	6.70	6.95	6.90	6.05	6.50	.....	3.60	.....	.....	4.50	5.80	6.05
18	6.55	6.80	6.90	6.90	6.60	.....	3.00	.....	.....	4.50	5.80	6.40
19	6.55	6.80	6.80	7.35	6.70	.....	9.05	.....	7.25	4.50	5.90	6.50
20	6.55	6.80	6.50	7.80	7.45	.....	9.25	.....	6.05	4.50	6.00	6.45
21	6.60	6.80	6.40	7.95	7.40	.....	7.00	.....	5.50	4.50	6.00	6.55
22	6.50	6.80	6.40	7.95	7.30	.....	6.75	.....	5.15	4.50	6.10	6.55
23	6.60	6.80	6.40	7.80	7.30	.....	6.25	.....	5.00	4.50	6.20	6.60
24	6.70	6.70	6.40	7.70	7.20	.....	6.15	.....	5.00	4.60	6.20	6.65
25	6.70	6.80	6.40	7.70	7.00	.....	7.60	.....	.....	4.60	6.30	6.70
26	6.60	6.80	6.30	7.70	6.95	.....	7.50	.....	.....	4.70	6.30	6.65
27	6.60	6.80	6.30	7.70	6.80	.....	6.55	.....	.....	4.70	6.40	6.65
28	6.60	6.80	6.50	7.70	6.65	.....	6.30	.....	.....	4.80	6.40	6.65
29	6.60	.....	6.70	7.80	6.55	.....	6.20	.....	.....	4.80	6.50	6.75
30	6.60	.....	6.85	7.70	6.30	.....	6.25	.....	.....	4.90	6.50	6.85
31	6.65	.....	7.00	.....	6.20	.....	6.20	.....	.....	4.90	.....	6.80

June 8 to July 14, inclusive, no flow in river.
August 14 to September 8, inclusive, no flow in river.
September 15 to 18, inclusive, September 25 to October 22, inclusive, no flow in river.

RIO GRANDE AT EL PASO, TEXAS.

This is an important station, and measurements have been made ere for a long period. During the last three years the work has een carried on under the direction of W. W. Follett, consulting ngineer International (Water) Boundary Commission. This comission has had charge of the investigation looking toward the building of an international dam at El Paso. The present station is located t Courchesne's limekiln, 4 miles north of El Paso, Texas. The river eights are measured at the masonry pump foundation pier, 150 feet bove the kiln. The top of the downstream chisel draft is assumed o be at a gage height of 15 feet, and the distance to the water surface elow is measured with a carefully graduated rod. The left bank of ne river is formed by the loose rock fill of the Atchison, Topeka and anta Fe Railroad embankments, and will not overflow; the right

bank, however, is made ground and is liable to overflow at high stages. Owing to the shifting character of the bed of the stream, it has been necessary to make a large number of discharge measurements at this point in order to obtain an accurate idea of the discharge. Results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 259; 1897, Nineteenth Annual Report, Part IV, page 390; 1898, Twentieth Annual Report, Part IV, page 312. There were 32 discharge measurements made by T. M. Courchesne during 1899, as follows:

Measurements of Rio Grande at El Paso, Texas.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1899.	*Feet.*	*Second-ft.*	1899.	*Feet.*	*Second-ft.*
Jan. 4	6.40	290	Mar. 16	5.70	86
Jan. 9	6.10	226	Mar. 18	5.60	69
Jan. 12	6.00	173	Mar. 20	5.70	78
Jan. 14	5.90	126	Mar. 22	5.80	93
Jan. 16	5.90	126	Mar. 25	5.60	66
Jan. 18	6.40	244	Apr. 11	5.50	48
Jan. 21	6.30	249	Apr. 14	5.20	31
Jan. 23	6.10	181	May 8	6.90	336
Jan. 26	6.40	261	Dec. 14	5.40	94
Jan. 28	6.20	187	Dec. 16	5.30	70
Jan. 31	6.10	188	Dec. 18	5.10	49
Feb. 2	6.10	167	Dec. 20	5.10	47
Feb. 4	6.00	147	Dec. 23	5.20	56
Mar. 8	6.30	216	Dec. 26	5.30	72
Mar. 11	6.00	144	Dec. 28	5.50	101
Mar. 13	5.80	112	Dec. 30	5.40	104

Daily gage height, in feet, of Rio Grande at El Paso, Texas, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Dec.
1	6.15	6.10	6.25	6.05	7.45	(a)	(a)	5.70	(a)
2	6.20	6.10	6.15	5.50	7.60	(a)	(a)	5.00	(a)
3	6.40	6.00	6.20	5.05	7.50	(a)	(a)	5.00	(a)
4	6.40	6.00	6.15	5.05	7.40	(a)	(a)	4.90	(a)
5	6.25	5.90	6.20	5.05	7.30	(a)	(a)	4.85	4.30
6	6.15	6.25	6.20	5.00	7.10	(a)	(a)	4.65	4.40
7	6.10	6.50	6.25	4.95	6.85	(a)	(a)	4.45	4.50
8	6.10	6.30	6.30	5.10	6.85	(a)	(a)	4.15	4.50
9	6.10	6.40	6.20	5.25	6.55	(a)	(a)	.....	4.50
10	6.10	6.40	6.10	5.40	6.30	(a)	(a)	.....	4.50
11	6.00	6.40	6.00	5.50	6.00	(a)	(a)	.....	4.50
12	6.00	6.30	5.90	5.40	5.85	(a)	(a)	.....	4.75
13	5.90	5.90	5.80	5.25	5.65	(a)	(a)	.....	5.10
14	5.90	6.20	5.80	5.20	5.70	(a)	(a)	.....	5.40
15	5.90	6.00	5.75	5.10	5.55	(a)	(a)	.....	5.40
16	5.90	6.00	5.70	5.10	5.40	(a)	(a)	.....	5.30
17	6.20	6.00	5.65	5.10	5.50	(a)	(a)	.....	5.20
18	6.40	6.05	5.60	4.90	5.15	(a)	4.45	.....	5.10
19	6.40	6.20	5.60	4.90	4.95	(a)	5.35	.....	5.10
20	6.40	6.10	5.70	4.90	4.85	(a)	6.60	.....	5.10
21	6.30	6.20	5.80	4.95	4.80	(a)	7.90	.....	5.10
22	6.30	6.50	5.80	5.00	4.70	(a)	9.05	.....	5.15
23	6.10	6.55	5.65	5.35	4.60	(a)	9.05	.....	5.20
24	6.20	6.35	5.60	7.45	4.60	(a)	8.40	.....	5.20
25	6.25	6.30	5.60	7.60	4.60	(a)	8.20	.....	5.20
26	6.35	6.30	5.45	7.50	4.60	(a)	7.85	.....	5.30
27	6.30	6.25	5.45	7.30	4.60	(a)	7.55	.....	5.25
28	6.20	6.20	5.50	7.20	4.60	(a)	6.90	.....	5.40
29	6.20	.....	5.40	7.30	4.60	(a)	6.70	.....	5.50
30	6.10	.....	5.40	7.30	4.55	(a)	6.65	.....	5.40
31	6.10	.....	5.75	.....	4.50	(a)	6.35	.....	5.40

a Not flowing from June 1 to July 17 and from August 9 to November 30.

PECOS RIVER AT PECOS, TEXAS.

This stream rises on the eastern slope of the Santa Fe Range in northern New Mexico. Its course is first southerly, through a typical mountainous and canyon country, until it reaches Fort Sumner, when the character of the topography changes. The river then takes a more southerly course and the country then changes from a rolling to an almost flat area. A number of large irrigation enterprises have been completed within the last few years and now irrigate large areas n the vicinity of Roswell and Eddy, New Mexico, and even extend lown into Texas. The summer flow of the river is largely dependent ıpon numerous springs, which occur in the limestone country in the 'icinity of Roswell and below. Owing to the numerous diversions or irrigating purposes, however, the river would be dry in the summer where it crosses into Texas were it not for the waters which are radually returning to the river through seepage. This water, unfornnately, is impregnated to a considerable extent with alkali, which enders it undesirable for irrigating purposes. The station on this iver was established January 1, 1898, and is located at a point 6 iiles above the town of Pecos, Texas, at the flume of the Margueretta anal. This canal diverts water from the river 3 miles above this oint on the west side, and then the water is carried over to the east ide by means of a flume, where it is used below. The bench mark f the gage is the top of north pier at west side of flume, and its levation is 20.7 feet above gage datum. The channel at this point is early straight, the water sluggish, the banks high, and the bottom andy and shifting. One measurement of the discharge in the flume vas made on June 22, when it was found to be 85 second-feet. Two neasurements were made on the main river by Prof. Thomas U. Taylor in 1899, as follows: June 22, at a gage height of 0.70 foot, the lischarge was 21 second-feet; the second measurement, on December 8, at a gage height of 2.90 feet, gave a discharge of 345 second-feet.

In the vicinity of Fort Stockton, Pecos County, Texas, occur a series of springs which contribute to the discharge of Comanche Creek, a ributary of Pecos River. On June 23, 1899, their discharge was neasured by Prof. Thomas U. Taylor at the ford one-half mile east of the court-house, and the discharge was found to be 66 second-feet.

Daily gage height, in feet, of Pecos River at Pecos, Texas, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.80	3.00	2.80	1.00	1.00	0.45	0.75	5.35	1.30	1.25	1.30	3.00
2	2.80	3.00	2.70	1.00	1.00	.45	.90	4.80	1.30	1.20	1.30	2.90
3	2.60	3.00	2.60	1.00	1.00	.40	.70	3.75	1.30	1.20	1.30	2.85
4	2.60	2.95	2.50	1.00	1.00	.40	.80	3.65	1.25	1.85	1.30	2.90
5	2.60	2.80	2.50	1.00	1.00	.40	.80	3.45	1.20	1.80	1.35	2.90
6	2.55	2.65	2.75	1.00	1.00	.40	.80	2.65	1.20	1.50	1.40	2.90
7	2.50	2.45	2.65	1.00	1.00	.40	.80	2.15	1.20	1.50	1.40	3.00
8	2.50	2.40	2.55	1.00	1.00	.40	1.50	2.05	1.20	1.45	1.40	3.05
9	2.50	2.70	2.35	1.00	1.55	.40	3.75	1.90	1.30	1.35	1.45	3.00
10	2.50	3.00	2.10	1.00	1.50	.40	2.20	1.75	1.50	1.30	1.45	3.10
11	3.10	3.00	1.80	.95	1.00	1.75	1.00	1.70	2.45	1.30	1.50	3.00
12	3.10	2.90	1.45	.90	1.00	1.00	1.35	1.80	1.85	1.20	1.40	2.90
13	3.10	2.85	1.35	.90	1.00	.60	1.15	2.20	3.00	1.20	1.40	3.00
14	3.00	3.00	1.30	.90	1.00	.60	1.00	2.15	2.40	1.20	1.40	3.00
15	3.00	3.00	1.20	1.10	.95	.60	.85	2.05	1.80	1.20	1.40	3.00
16	3.00	3.00	1.20	3.50	.90	1.60	1.15	2.00	1.65	1.35	1.40	3.00
17	3.00	2.90	1.10	2.75	.70	2.30	.80	2.00	1.35	1.10	1.30	3.00
18	3.00	2.80	1.10	1.95	.50	1.15	4.35	1.95	1.30	1.10	1.30	3.10
19	3.00	2.70	1.10	1.60	.50	.85	1.95	1.30	1.30	1.10	2.65	3.10
20	3.00	2.70	1.10	1.45	.50	.70	3.00	1.40	1.40	1.00	4.40	3.10
21	3.00	2.70	1.20	1.35	.50	.70	3.00	1.30	1.00	1.00	3.30	3.20
22	3.00	2.70	1.15	1.30	.50	.70	2.65	1.40	2.00	1.00	2.60	3.30
23	3.00	2.70	1.10	1.30	.50	.70	3.05	1.40	2.65	1.10	2.25	3.05
24	2.95	2.60	1.10	1.15	.50	.70	4.25	1.40	2.45	1.10	2.05	3.25
25	2.90	2.50	1.10	1.10	.50	.70	5.00	1.40	2.00	1.10	2.00	3.80
26	3.05	2.75	1.30	1.10	.50	.70	5.55	1.40	1.80	1.10	2.00	3.15
27	3.00	2.70	1.10	1.10	.50	.70	5.60	1.40	1.50	1.20	2.00	3.05
28	3.00	2.70	1.00	1.10	.50	.70	5.50	1.30	1.45	1.20	2.55	3.00
29	3.05	.....	1.00	1.00	.50	.70	5.50	1.30	1.40	1.20	2.50	2.90
30	3.00	.....	1.00	1.00	.50	.70	5.50	1.30	1.35	1.20	2.45	2.90
31	3.00	.....	1.00	.....	.50	.....	5.50	1.30	.....	1.30	.....	2.95

GREEN RIVER AT GREENRIVER, WYOMING.

This river has its source in the Wind River and Gros Ventre mountains in western Wyoming; it flows southerly, receiving a number of important tributaries from either side, and after crossing the State line flows through Utah. In this State its principal tributaries are Yampa and White rivers from the east and Duchesne River from the west. Sixty miles below the crossing of the Rio Grande Western Railway in Utah, Green River joins the Grand River to form the Colorado. Two gaging stations have been maintained on the main river, one at Greenriver, Wyoming, at the crossing of the Union Pacific Railroad, and the other at Blake, Utah, at the crossing of the Rio Grande Western Railway. The former station, established May 2, 1895, is located at the pump house of the Union Pacific Railroad Company. The rod is fastened to a pile near the east end of the bridge. The bench mark consists of a cross on the third step from the bottom on the south end of the east abutment, and is 12.48 feet above gage datum. The rod was last verified with the bench mark August 30, 1899. As the section under the railroad bridge is poor, discharge measurements are made from the iron highway bridge about one-half mile below. The average annual discharge of Green River at this point having been determined for the last five years, and as the water supply is far greater than the demand by irrigators, observations will be discontinued in the spring and attention given to the

more important tributaries of the river. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 275; 1897, Nineteenth Annual Report, Part IV, page 395; 1898, Twentieth Annual Report, Part IV, page 380. The following discharge measurements were made by A. J. Parshall during 1889:

April 19, gage height, 1.35 feet; discharge, 1,595 second-feet.
May 13, gage height, 2.20 feet; discharge, 2,661 second-feet.
May 25, gage height, 2.55 feet; discharge, 3,422 second-feet.
June 7, gage height, 3.80 feet; discharge, 8,234 second-feet.
June 20, gage height, 5.30 feet; discharge, 15,305 second-feet.
July 5, gage height, 6.25 feet; discharge, 18,372 second-feet.
August 30, gage height, 2.10 feet; discharge, 1,632 second-feet.

Daily gage height, in feet, of Green River at Greenriver, Wyoming, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		1.80	1.90	1.00	1.78	3.20	6.38	3.88	2.05	1.45	1.60	1.20
2				.70	1.58	3.25	6.43	3.78	2.05	1.45		
3	1.50			.95	1.50	3.35	6.50	3.70	1.95	1.45	1.60	1.20
4				1.10	1.43	3.48	6.43	3.68	1.90	1.40		
5				.90	1.33	3.55	6.13	3.65	1.90	1.40	1.60	1.40
6				.80	1.30	4.00	5.85	3.65	1.90	1.40		
7				.90	1.33	3.95	5.75	3.58	1.90	1.40	1.55	1.45
8		1.80	1.70	.85	1.50	3.70	5.73	3.53	1.85	1.45		
9	1.60			.95	1.50	3.45	5.65	3.50	1.85	1.45	1.55	1.45
10				.90	1.63	3.38	5.60	3.45	1.80	1.45		
11				1.30	1.95	3.43	5.53	3.40	1.78	1.48	1.50	1.45
12				1.35	2.15	3.73	5.45	3.40	1.73	1.50		
13	1.60			1.50	2.28	4.13	5.45	3.35	1.78	1.55	1.50	1.45
14				1.50	2.55	4.68	5.48	3.23	1.85	1.58		
15		1.90	1.30	1.60	2.58	4.73	5.53	3.13	1.80	1.60	1.50	1.45
16				1.50	2.80	4.35	5.45	3.00	1.75	1.60		
17				1.40	2.78	4.30	5.38	2.95	1.75	1.60	1.50	1.40
18				1.40	2.65	4.50	5.23	2.93	1.75	1.60		
19	1.60			1.35	2.63	4.93	4.95	2.83	1.73	1.63	1.45	1.40
20				1.35	2.50	5.40	4.73	2.68	1.70	1.65		
21				1.30	2.80	5.80	4.63	2.60	1.65	1.68	1.40	1.45
22		1.90	1.30	1.25	2.78	6.18	4.50	2.55	1.65	70		
23				1.35	2.73	6.50	4.45	2.53	1.60	70	1.30	1.45
24				1.45	2.58	6.63	4.40	2.50	1.60	1.70		
25	1.70			1.65	2.55	6.30	4.33	2.45	1.60	1.65	1.25	1.50
26				2.00	2.78	6.05	4.18	2.40	1.55	1.65		
27	1.70			1.95	3.08	5.98	4.03	2.38	1.55	1.63	1.25	1.55
28		1.90		1.90	3.18	6.03	3.98	2.30	1.50	1.60		
29			1.70	1.90	3.20	6.10	3.95	2.23	1.50	1.60	1.25	1.55
30	1.55			1.83	3.25	6.28	3.95	2.10	1.45	1.60		1.60
31					3.20		3.95	2.05		1.60		

BLACK FORK AT GRANGER, WYOMING.

This tributary of Green River rises in the extreme southwestern corner of Wyoming, and flows in a general northwesterly direction until after its junction with Hams Fork, when it turns southeasterly and joins Green River 20 miles below Greenriver station, Wyoming. Considerable irrigation is practiced on its head-water streams, almost wholly for forage crops, as the elevation is too high for diversified farming. The general industry of the country is stock raising, the herds being ranged on the hillside during the summer, and during the winter fed the hay raised by irrigation. The station on this river was established April 28, 1897, and is located below the mouth of Hams Fork and about a quarter of a mile below Granger. The rod consists of a horizontal timber fastened to two upright posts set firmly in the bank of the river. One end of the timber to which the wire gage is

fastened projects out over the water. The bench mark is a rail spike in an old tie 25 feet west of inside post of gage, marked "B. M." in black paint, and is at an elevation of 8.74 feet above gage datum. The rod was last verified with the bench mark August 30, 1899. The results of measurements may be found as follows: 1897, Nineteenth Annual Report, Part IV, page 393; 1898, Twentieth Annual Report, Part IV, page 382. The following discharge measurements were made by A. J. Parshall during 1899:

April 19, gage height, 1.85 feet; discharge, 769 second-feet.
May 13, gage height, 3.30 feet; discharge, 2,229 second-feet.
May 25, gage height, 3.60 feet; discharge, 2,535 second-feet.
June 7, gage height, 5.10 feet; discharge, 4,776 second-feet.
June 20, gage height, 5.70 feet; discharge, 5,567 second-feet.
July 5, gage height, 3.90 feet; discharge, 2,674 second-feet.
August 30, gage height, 0.20 foot; discharge, 101 second-feet.

Daily gage height, in feet, of Black Fork at Granger, Wyoming, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	2.20	.....	1.80	3.90	4.40	1.50	0.80	0.30	.....	.....
2	1.80	.....	.....	2.90	2.20	3.90	4.50	1.40	.80	.30	.....	1.30
3	.....	.....	.....	2.90	2.65	3.90	4.60	1.40	.80	.30	.....	.....
4	.....	2.10	.....	2.90	1.60	4.20	4.30	1.40	.70	.30	0.80	.....
5	.....	.....	.....	2.95	1.70	4.30	3.90	1.40	.65	.35	.....	.....
6	.....	.....	.....	3.20	1.60	4.50	3.80	1.40	.60	.40	.....	.....
7	.....	.....	.....	3.25	1.70	5.05	3.60	1.40	.60	.50	.....	.....
8	.....	.....	2.30	1.80	1.90	5.40	3.50	1.60	.60	.50	.....	.....
9	1.60	.....	.....	1.80	2.00	5.20	3.30	1.50	.60	.50	.....	1.00
10	.....	.....	.....	1.60	2.20	4.90	3.10	1.50	.60	.50	.....	.....
11	.....	2.10	.....	1.40	2.65	4.85	3.10	1.50	.50	.50	.80	.....
12	.....	.....	.....	1.60	2.75	5.10	3.00	1.50	.50	.60	.....	.....
13	.....	.....	.....	1.65	3.35	5.50	3.20	1.25	.50	.60	.....	.....
14	.....	.....	.....	1.60	3.80	6.05	3.20	1.20	.50	.70	.....	.....
15	.....	.....	2.50	1.70	4.20	6.05	3.20	1.20	.50	.70	.....	.....
16	1.70	.....	.....	1.80	4.50	5.60	3.10	1.20	.50	.70	.....	1.00
17	.....	.....	.....	1.75	4.50	5.50	3.20	1.10	.40	.70	.....	.....
18	.....	2.20	.....	1.60	4.10	5.40	2.90	1.10	.40	.70	.90	.....
19	.....	.....	.....	1.85	3.80	5.50	2.55	1.00	.45	.70	.....	.....
20	.....	.....	.....	2.10	3.90	5.70	2.30	1.00	.50	.80	.....	.....
21	.....	.....	.....	1.50	4.00	5.90	2.20	.95	.50	.70	.....	.....
22	1.90	.....	2.70	1.50	3.80	6.25	2.05	.90	.50	.70	.....	.....
23	.....	.....	.....	1.60	3.80	6.00	2.00	.90	.50	.80	.....	1.50
24	.....	.....	.....	1.85	3.30	5.50	1.90	.80	.50	.80	.....	.....
25	.....	2.30	.....	1.80	3.60	5.30	1.90	.70	.40	.80	.90	.....
26	.....	.....	.....	2.00	4.10	5.00	1.80	.70	.40	.80	.....	.....
27	.....	.....	.....	2.20	4.20	4.70	1.80	.70	.30	.80	.....	.....
28	1.90	.....	.....	2.00	4.30	4.60	1.80	.70	.30	.70	.....	.....
29	.....	.....	3.80	1.80	4.30	4.40	1.80	.70	.30	.70	.....	.....
30	.....	.....	.....	1.80	3.90	4.30	1.70	.70	.30	.75	.....	1.30
31	.....	.....	.....	.....	3.90	.....	1.50	.70	.....	.80	.....	.....

UINTA RIVER NEAR WHITEROCKS, UTAH.

Uinta River has its source on the southern slope of the Uinta Mountains in northeastern Utah, and flows in a general southeasterly direction, emptying into Duchesne River about 15 miles above its mouth. Its drainage area is included within the Uinta Indian Reservation. During the fall of 1899 an investigation of the water supply of the Uinta Indian Reservation was begun by Cyrus C. Babb, and in this connection a number of gaging stations were established. Uinta River emerges from its canyon about 10 miles northwest of the Indian agency at Whiterocks, and at this point a gaging station was estab-

ıed September 16, 1899. The gage rod is a 2 by 4 inch timber, 12 ›t long, bolted to two trees on the left bank of the stream. The nch mark is a nail in an aspen tree 125 feet north of the rod, and its ›vation is 8.93 feet above gage datum. Discharge measurements are ıde by car and cable. The bed of the stream is very rocky and strewn ith large bowlders, and the station is not altogether satisfactory, ı account of the roughness of the channel. During high water the ›locity undoubtedly will be great, owing to the rapid fall of the water. . few hundred yards above the station an important tributary comes ı from the east. At the present location a second channel has to be ıeasured, but it will never carry a large volume of water. Farther own the stream a number of larger channels are formed, so that it is ifficult to obtain a satisfactory station. Daily records of gage heights ere not maintained at this point, but frequent measurements of dis-harge were made by Cyrus C. Babb and C. T. Prall during 1899, as ollows:

Measurements of Uinta River near Whiterocks, Utah.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
September 16	1.15	191	November 25	1.00	119
September 28	1.00	142	December 4	1.00	136
October 6	1.00	159	December 11	.97	136
October 18	1.10	165	December 18	1.00	124
November 2	1.00	141	December 28	(a)	86

a Ice.

WHITEROCKS RIVER NEAR WHITEROCKS, UTAH.

This stream drains the country immediately east of the head waters ' Uinta River. It has its source in the peaks of the Uinta Mountains, hich attain elevations of over 13,000 feet. The general course of the ver is southerly, and it joins the main Uinta through numerous chan-›ls between Whiterocks and Fort Duchesne. A gaging station was tablished in the canyon of this river about 10 miles above the United tates Indian agency at Whiterocks on September 15, 1899, by Cyrus . Babb, in connection with the investigation of a water supp y for the inta Indian Reservation. The gage rod consists of a 2 by 4 inch by ? foot timber bolted to the triple trunk of a tree on the left bank of ıe stream. The bench mark is a nail in a burnt tree 50 feet east of the d, and is at an elevation of 10.12 feet above gage datum. Discharge easurements are made from a car and cable 200 feet above the gage d. The bed of this river is very rocky, is strewn with large bowlders, d although permanent in character is not altogether satisfactory cause of the fact that it is impossible to obtain accurate soundings. ıily gage heights were not read at this point, owing to its distance

from any reliable observer. The following discharge measurements were made by C. C. Babb and C. T. Prall during 1899:

Measurements of Whiterocks River near Whiterocks, Utah.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
September 15	.....	95	November 27	1.05	66
September 29	1.00	58	December 5	1.10	71
October 7	1.00	75	December 12	.95	58
October 17	1.10	85	December 19	.95	56
November 1	1.00	65	December 29	(a)	66

a Ice.

UINTA RIVER AT FORT DUCHESNE, UTAH.

This river, on its emergence from its canyon, spreads out in numerous channels over its flood plain until a short distance above Fort Duchesne, where its waters are collected in one channel. Whiterocks River enters some distance above this point. A number of canals for the use of the Indians divert water between Fort Duchesne and the agency. On the east side are a number of small ditches, which in the aggregate take considerable water; but the amount is difficult to estimate. On the east side are two principal ditches, known as Canal No. 1 and Bench ditch. The former was measured on October 14, 1899, and was then carrying 16 second-feet; its maximum capacity is about double this quantity. Bench ditch, near its head, on the same day, was discharging 49 second-feet; its maximum capacity is somewhere in the neighborhood of 75 second-feet. This station was established September 14, 1899, in connection with the investigation of the water supply for the Uinta Indian Reservation, and is located at the highway bridge at the fort. The permanent rod was established November 8, 1899, and is nailed to the southern end of the east crib of the new bridge. The bench mark is a nail in the southeast crib in the first header above the bottom, and is at an elevation of 4,910.13 feet. The elevation of the zero of the rod is 4,907.20 feet. Daily gage readings were not obtained at this place. The following measurements of discharge were made by Cyrus C. Babb and C. T. Prall during 1899:

Measurements of Uinta River at Fort Duchesne, Utah.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
September 14	.....	86	December 1	2.55	120
September 26	2.30	71	December 8	2.43	112
October 27	2.40	83	December 13	2.40	107
November 3	2.50	102	December 21	2.35	102
November 18	2.57	120	December 27	2.59	131

UINTA RIVER AT OURAY SCHOOL.

This river, after leaving Fort Duchesne, receives as its principal tributary Dry Gulch Creek, which enters from the west. The natural flow of this tributary occurs only during flood stages, but for several years there has been a constant stream in it, being the waste water from the Indians' ditches above, principally from Canal No. 1 and Bench ditch. The station was established November 8, 1899, and is located at the highway bridge over the river near the Ouray School. The rod is nailed to the east end of the south crib of the wagon bridge. Bench mark No. 1 is the head of a nail in the extreme northeast corner of the bridge floor, and is at an elevation of 4,745.97 feet above sea; bench mark No. 2 is a nail in the flagstaff of the school, with an elevation of 4,760 feet. The elevation of the zero of the rod is 4,737.36 feet. During low water measurements are made, by wading, at a section 200 feet below the bridge, and at high stages they are made from the bridge itself. The section is a good one, although the center pier of the bridge will interfere somewhat with the accuracy of the results when measurements are taken there. The following measurements of discharge were made by Cyrus C. Babb and C. T. Prall during 1899:

November 15, gage height, 0.53 foot; discharge, 124 second-feet.
November 20, gage height, 0.56 foot; discharge, 124 second-feet.
December 2, gage height, 0.49 foot; discharge, 120 second-feet.
December 9, gage height, 0.50 foot; discharge, 115 second-feet.
December 16, gage height, 0.45 foot; discharge, 103 second-feet.

Daily gage height, in feet, of Uinta River at Ouray School, Utah, for 1899.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1	.....	0.51	9	.....	.52	17	0.68	.....	25	0.46	.....
2	.....	.50	10	.....	.....	18	.64	.....	26	.51	.....
3	.....	.30	11	.....	.....	19	.60	.....	27	.46	.....
4	.....	.18	12	0.57	.....	20	.58	.....	28	.61	.....
5	.....	.40	13	.55	.....	21	.55	.....	29	.58	.....
6	.....	.40	14	.58	.....	22	.50	.....	30	.50	.....
7	.....	.....	15	.57	.....	23	.59	.....	31	.....	.....
8	.....	.60	16	.99	.....	24	.52	.....			

DUCHESNE RIVER AT PRICE ROAD BRIDGE, UTAH.

This stream has its source in the high peaks of the Uinta and Wasatch mountains, and flows in a general easterly direction, emptying into Green River 3 miles above the mouth of White River. Practically the entire drainage basin is included within the Uinta Indian Reservation. Strawberry Creek is an important tributary of the Duchesne and includes within its basin a tract of very fine grazing land, known as Strawberry Valley. The area is of a rolling character in contrast to the basin of the upper Duchesne, which is distinctly mountainous. A number of measurements were made of the tributaries of Duchesne

River in the fall of 1899, in connection with the water-supply investigations for the Uinta Indian Reservation. In Strawberry Valley a number of small tributaries, averaging about one second-foot each, contribute to the supply of the river. In September, 1899, Currant Creek was discharging 20 second-feet at the crossing of the Provo and Fort Duchesne road. Red Creek, farther to the east, was at the same date carrying 8 second-feet. Strawberry Creek 4 miles above its mouth was measured on September 10 and found to be carrying 134 second-feet. Duchesne River immediately above Strawberry Creek was carrying on the same day 302 second-feet. Lake Creek is an important tributary of Duchesne River from the north. At the bridge near its mouth it was found to be carrying 128 second-feet on September 11. The station on Duchesne River was established October 26, 1899, and is located 3 miles below the mouth of Lake Creek at the highway bridge on the stage road from Price to Fort Duchesne. The permanent gage rod was placed November 16, 1899, and is nailed to the east side of the center pier. Bench mark No. 1 is a wire nail in a log close to the rod, and is opposite the 7-foot mark. Bench mark No. 2 is a wire nail on the west side of the crib, with an elevation of 5.48 feet above gage datum. The section at this point is very good, with a moderate velocity of water. There is one pier in the center of the stream which does not materially affect the accuracy of the results at low water, but presumably will to a certain extent during the flood season. The following measurements of discharge were made by Cyrus C. Babb and C. T. Prall during 1899:

October 26, gage height, 5.48 feet; discharge, 403 second-feet.
November 16, gage height, 5.50 feet; discharge, 436 second-feet.
November 29, gage height, 5.38 feet; discharge, 360 second-feet.
December 7, gage height, 5.50 feet; discharge, 386 second feet.
December 14, gage height, 5.10 feet; discharge, 309 second-feet.

Daily gage height, in feet, of Duchesne River at Price road bridge, Utah, for 1899.

Day.	Dec.	Day.	Dec.	Day.	Dec.	Day.	Dec.	Day.	Dec.
1	.....	8	5.52	14	5.00	20	5.40	26	5.94
2	.....	9	5.52	15	5.05	21	5.35	27	5.28
3	5.32	10	5.04	16	5.06	22	5.45	28	6.00
4	5.32	11	5.04	17	5.15	23	5.65	29	6.00
5	5.36	12	5.00	18	5.40	24	5.75	30	6.00
6	5.20	13	5.00	19	5.40	25	5.92	31	.....
7	5.52								

GREEN RIVER AT BLAKE, UTAH.

This river, in the lower portion of its course, drains a rough and broken country in eastern Utah not susceptible of irrigation and hardly adapted to grazing purposes. It is in canyon most of its way below the Rio Grande Western Railway and is very inaccessible. About 60

iles below the railroad crossing it receives the waters of Grand River, nd the two streams form Colorado River. The station located at lake, Utah, was established October 21, 1894. The rod of the wire age is nailed to the guard rail on the lower side of the railroad bridge. he elevation of the top of the pier, to which the old vertical rod is tached, is 22 feet above gage datum. The results of measurements ay be found as follows: 1896, Eighteenth Annual Report, Part IV, age 278; 1897, Nineteenth Annual Report, Part IV, page 398; 1898, wentieth Annual Report, Part IV, page 387. One measurement of ischarge was made during 1899 by J. S. Baker, on June 28, when, at gage height of 10.19 feet, a discharge of 52,378 second-feet was found.

Daily gage height, in feet, of Green River at Blake, Utah, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	1.80	2.10	2.00	3.55	5.85	7.15	9.55	5.40	3.25	2.50
2	1.80	2.10	2.00	3.50	5.65	7.25	9.35	5.15	3.20	2.40
3	1.80	2.20	2.10	3.50	5.55	7.35	9.15	5.20	3.20	2.40
4	1.80	2.20	2.10	3.50	5.25	7.45	8.95	6.60	3.20	2.40
5	1.80	2.10	2.20	3.40	5.05	7.55	8.75	6.55	3.20	2.40
6	1.80	2.10	2.20	3.40	4.85	7.65	8.55	6.40	3.10	2.40
7	1.80	2.10	2.20	3.40	4.95	7.75	8.40	6.30	3.10	2.40
8	1.80	2.10	2.20	3.30	5.15	7.85	8.30	6.15	3.10	2.40
9	1.80	2.10	2.20	3.30	5.50	8.05	8.20	6.00	3.10	2.40
10	1.80	2.10	2.30	3.20	5.90	8.20	8.10	5.85	3.00	2.40
11	1.80	2.10	2.30	3.20	6.15	8.30	8.00	5.65	3.00	2.40
12	1.80	2.10	2.30	3.30	6.35	8.40	7.90	5.45	3.00	2.40
13	1.90	2.10	2.30	3.30	6.55	8.50	7.80	5.25	2.90	2.40
14	1.90	2.00	2.30	3.30	6.65	8.50	7.70	5.20	2.85	2.40
15	1.90	2.00	2.35	3.40	6.95	8.65	7.60	5.10	2.80	.....
16	1.90	2.00	2.40	3.50	7.30	8.90	7.50	5.00	2.80	.....
17	1.90	2.00	2.40	3.60	7.55	9.20	7.40	4.95	2.80	.....
18	1.90	2.10	2.40	3.75	7.75	9.15	7.30	4.85	2.70	.....
19	2.00	2.10	2.50	3.95	7.75	9.10	7.15	4.75	2.70	.....
20	2.00	2.10	2.60	4.15	7.65	9.40	7.00	4.65	2.65	.....
21	2.00	2.00	2.70	4.35	7.60	9.50	6.85	4.55	2.60	.....
22	2.00	2.00	2.85	4.55	7.60	9.75	6.65	4.45	2.60	.....
23	2.00	2.00	3.05	4.75	7.50	9.90	6.45	4.25	2.55	.....
24	2.00	2.00	3.25	4.95	7.50	10.00	6.25	4.05	2.50	.....
25	2.10	2.00	3.45	5.05	7.40	10.05	6.05	3.85	2.50	.....
26	2.10	2.00	3.65	5.25	7.25	10.25	5.90	3.65	2.50	.....
27	2.20	2.00	3.85	5.45	7.05	10.30	5.75	3.50	2.50	.....
28	2.20	2.00	4.05	5.65	6.90	10.15	5.60	3.50	2.50	.....
29	2.20	.....	4.25	5.85	6.95	9.95	5.50	3.45	2.50	.....
30	2.20	.....	4.10	6.00	7.05	9.75	5.50	3.40	2.50	.....
31	2.20	.....	3.75	.....	7.10	.....	5.45	3.30	.....	.....

Station discontinued November 15.

GRAND RIVER AT GLENWOOD SPRINGS, COLORADO.

This river has its source on the western slope of the Continental Divide in north-central Colorado, near the head waters of North Platte, South Platte, and Arkansas rivers. It flows in a general southwesterly direction, passing out of the State into Utah, where it joins the Green River to form the Colorado. Little irrigation is practiced along the main stream, owing to the comparatively small area of land that can be utilized for that purpose. Two stations were maintained on this river during 1899, one at Glenwood Springs and the other at Grand Junction, Colorado. The former station was established by A. L. Fellows May 12, 1899, at the request of the Denver and Rio Grande

Railroad Company, and is located at the railroad bridge one-fourth of a mile west of the railroad station, and above the mouth of Roaring Fork. A wire gage is here used. Discharge measurements are made at the wagon bridge opposite Colorado Hotel in the town. The channel is good, composed of gravel and rock, and not liable to great changes. The banks are not subject to overflow. Gage readings were taken only during the high-water season, having been discontinued July 17, but the station will probably be resumed in 1900, when continuous measurements will be made. Roaring Fork was measured twice during the year, the first time on June 17, when, during the flood stage, the discharge was found to be 11,258 second-feet; the second time on November 17, when a discharge of 457 second-feet was found. Three measurements at the gaging station were made by A. L. Fellows in 1899. The first, on May 12, at a gage height of 6.05 feet, showed a discharge of 17,577 second-feet; the second, on June 17, at a gage height of 10.22 feet, showed a discharge of 29,187 second-feet; the third, on November 17, at a gage height of 2.75 feet, gave a discharge of 1,084 second-feet.

Daily gage height, in feet, of Grand River at Glenwood Springs, Colorado, for 1899.

Day.	May.	June.	July.	Day.	May.	June.	July.	Day.	May.	June.	July.
1	.....	7.50	6.90	12	6.05	9.35	5.90	23	6.20	9.70	.....
2	.....	7.40	7.10	13	6.80	10.05	5.60	24	6.30	9.30	.....
3	.....	7.35	7.00	14	7.50	10.40	5.30	25	6.65	8.80	.....
4	.....	7.20	7.00	15	7.85	10.30	5.00	26	7.15	8.50	.....
5	.....	6.65	6.80	16	8.15	10.10	4.90	27	7.65	8.40	.....
6	.....	6.45	6.70	17	7.75	10.10	4.70	28	7.70	8.20	.....
7	.....	6.40	6.50	18	7.65	10.20	.....	29	7.45	7.20	.....
8	.....	6.60	6.40	19	7.80	10.60	.....	30	7.50	7.00	.....
9	.....	7.60	6.40	20	8.00	10.65	.....	31	7.60	.....	.....
10	.....	7.85	6.20	21	7.50	10.60	.....				
11	.....	8.25	6.10	22	6.75	10.40	.....				

Station discontinued July 18.

GRAND RIVER AT GRAND JUNCTION, COLORADO.

The station at this point, established October 18, 1894, is located at the wagon bridge across Grand River, near the pump house of the city waterworks at Grand Junction and a short distance above the mouth of Gunnison River. The river at this point discharges through two channels, and a separate record of each is maintained, with separate discharge measurements. The water in the right-hand channel does not run during the entire year, and in 1899 there was a discharge in it extending only from May 10 to July 15, inclusive. Gage rod No. 1, in the right-hand channel, consists of a 4 by 6 inch timber bolted to the bridge abutment on the right-hand side of the right channel. The bench mark is the top of the bridge abutment and is 12 feet above gage datum. The horizontal wire gage No. 2 is fastened to the upper side

: bridge over the left channel. The bench mark is a cross on iron of bridge at 592-foot mark on right abutment, and is 31 feet above datum. The results of measurements may be found as follows: Eighteenth Annual Report, Part IV, page 261; 1897, Nineteenth ual Report, Part IV, page 401; 1898, Twentieth Annual Report, IV, page 389. Only two measurements of discharge were made ıg the year on the right channel, and these by A. L. Fellows. The on May 13, with a gage height of 3.15 feet, gave a discharge 758 second-feet; the second, on June 18, with a gage height of feet, showed a discharge of 8,954 second-feet. During 1899 the wing measurements of discharge on the left channel were made .. L. Fellows:

April 15, gage height, 4.70 feet; discharge, 2,946 second-feet.
May 13, gage height, 10 feet; discharge, 20,395 second-feet.
June 18, gage height, 11.55 feet; discharge, 30,000 second-feet.
September 19, gage height, 4.20 feet; discharge, 1,989 second-feet.
November 18, gage height, 3.90 feet; discharge, 1,916 second-feet.

ily gage height, in feet, of Grand River at Grand Junction, Colorado, for 1899.

[Rod No. 1.]

.	May.	June.	July.	Day.	May.	June.	July.	Day.	May.	June.	July.
..	.....	3.90	3.90	12....	1.95	4.85	0.90	23....	2.70	5.80	.....
..	.....	3.95	4.00	13....	3.05	5.45	.95	24....	2.60	5.20	.....
..	.....	3.80	4.10	14....	3.55	5.80	.80	25....	2.95	4.85	.....
..	.....	3.40	3.90	15....	4.00	5.90	.20	26....	3.35	4.70	.....
..	.....	3.05	3.40	16....	4.30	5.85	.....	27....	3.85	4.50	.....
..	.....	2.95	2.90	17....	4.45	5.75	.....	28....	4.10	4.10	.....
..	.....	2.95	2.65	18....	4.10	5.70	.....	29....	3.85	4.00	.....
..	.....	3.25	2.25	19....	4.20	5.90	.....	30....	3.80	3.95	.....
..	.....	3.45	1.90	20....	4.20	6.10	.....	31....	3.95	.....	.....
..	0.40	3.90	1.50	21....	4.15	6.45	.....				
..	.90	4.35	1.20	22....	3.50	6.10	.....				

Water was running in this channel only during the time when records are given.

Daily gage height, in feet, of Grand River at Grand Junction, Colorado, for 1899.

[Rod No. 2.]

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	3.80	3.40	6.75	10.50	10.30	6.50	4.45	.....	.....	.....
2	.....	3.80	3.45	6.45	10.55	10.50	6.50	4.65	.....	.....	.....
3	.....	3.80	3.55	6.30	10.45	10.50	6.40	4.60	3.80	.....	.....
4	.....	3.40	3.60	6.05	10.00	10.35	7.35	4.45	.....	.....	.....
5	.....	.....	3.60	5.80	9.50	9.90	7.00	4.35	.....	.....	.....
6	.....	.....	3.60	5.75	9.35	9.70	6.85	4.30	.....	.....	.....
7	.....	.....	3.60	6.00	9.30	9.55	6.65	4.20	.....	.....	.....
8	.....	3.60	3.60	6.40	9.55	9.30	6.45	4.20	.....	.....	.....
9	.....	.....	3.60	6.95	9.85	9.05	6.20	4.15	.....	.....	.....
10	.....	.....	3.70	7.50	10.30	8.85	5.90	4.10	3.90	3.90	.....
11	.....	3.60	3.75	8.15	10.45	8.70	5.75	4.10	.....	.....	.....
12	.....	.....	3.85	8.95	10.70	8.55	5.65	4.10	.....	.....	3.70 *a*
13	.....	.....	4.05	9.75	11.20	8.65	5.55	4.05	.....	.....	.....
14	.....	.....	4.40	10.25	11.60	8.55	5.45	3.95	.....	.....	.....
15	.....	3.40	4.60	10.65	11.70	8.40	5.40	4.10	.....	3.90	.....
16	.....	.....	4.65	10.85	11.65	8.35	5.35	4.35	.....	.....	.....
17	.....	.....	4.90	10.80	11.65	8.15	5.25	4.30	.....	.....	.....
18	.....	3.50	5.20	10.70	11.60	7.85	5.20	4.30	.....	.....	.....
19	.....	.....	5.45	10.80	11.80	7.65	5.15	4.20	4.40	.....	.....
20	.....	.....	5.55	10.80	11.90	7.45	4.95	4.15	.....	.....	.....
21	.....	.....	5.35	10.60	11.95	7.35	4.85	4.10	.....	.....	.....
22	4.10	3.80	5.15	10.05	11.80	7.25	4.75	4.05	.....	3.90	.....
23	4.10	.....	5.35	9.50	11.55	7.15	4.65	3.95	.....	.....	.....
24	4.10	.....	5.95	9.55	11.15	7.05	4.55	3.90	.....	.....	.....
25	4.00	4.10	6.55	9.95	10.90	6.95	4.50	3.90	.....	.....	.....
26	.....	.....	7.00	10.45	10.80	6.85	4.45	3.90	.....	.....	.....
27	.....	.....	7.55	10.75	10.65	6.65	4.40	3.95	4.00	.....	.....
28	.....	.....	7.70	10.70	10.45	6.60	4.30	3.90	.....	.....	.....
29	.....	3.70	7.25	10.45	10.40	6.55	4.30	3.90	.....	3.90	.....
30	.....	.....	7.10	10.40	10.35	6.50	4.30	3.90	.....	.....	.....
31	.....	.....	.....	10.60	.....	6.50	4.30	.....	.....	.....	.....

a River frozen.

UNCOMPAHGRE RIVER AT FORT CRAWFORD, COLORADO.

This river has its source in Ouray County, in the high peaks in southwestern Colorado, and flows in a general northwesterly direction, entering Gunnison River at Delta. The upper portion of its drainage basin is mountainous, but proceeding downstream the character changes to a more rolling country, and irrigation is possible along the valleys and adjacent mesas. In the vicinity of Montrose a number of canals divert nearly all of the low water flow, and recourse must be had to storage for the further irrigation of the country. The station established June 25, 1895, is located about one-half mile east of the depot at Fort Crawford, at a wagon bridge, and is about 8 miles above Montrose. The gage consists of an inclined timber bolted to the bridge trestle on the right-hand side of the stream. The bench mark is a spike driven into the base of a cottonwood post near by, and is 9.18 feet above gage datum. The channel has been changing a great deal, and a new location for the station will probably be found during the next season. On September 20 a measurement of this river was made at Montrose, at a gage height of 0.40 foot, which gave a discharge of 15 second-feet. On November 20, at a gage height of 0.45 foot, at the same point, the discharge was 15 second-feet. A measurement of Montrose canal at its head gate was made September 21, at a gage height of 0.67 foot, and showed a discharge of 30

nd-feet. Results of measurements may be found as follows: 1896, nteenth Annual Report, Part IV, page 266; 1897, Nineteenth ual Report, Part IV, page 402; 1898, Twentieth Annual Report, t IV, page 391. The following measurements of discharge were e by A. L. Fellows during 1899:

April 16, gage height, 4.50 feet; discharge, 328 second-feet.
May 15, gage height, 5.22 feet; discharge, 747 second-feet.
June 19, gage height, 5.18 feet; discharge, 773 second-feet.
September 21, gage height, 3.65 feet; discharge, 69 second-feet.
November 20, gage height, 3.70 feet; discharge, 79 second-feet.

y gage height, in feet, of Uncompahgre River at Fort Crawford, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	4.35	5.05	4.70	4.00	3.00	17	4.55	5.35	5.35	4.35	3.85	3.70
2	3.80	4.45	5.05	4.70	4.15	3.00	18	4.60	5.45	5.35	4.45	3.85	3.60
3	3.85	4.35	4.80	4.55	4.80	2.95	19	4.55	5.30	5.30	4.45	3.80	3.70
4	3.80	4.35	4.40	4.25	4.65	2.95	20	4.45	4.95	5.25	4.35	3.80	3.75
5	3.88	4.30	4.35	4.35	4.55	2.80	21	4.35	4.90	5.10	4.35	3.75	3.75
6	3.82	4.40	5.05	4.25	4.30	2.80	22	4.40	4.80	5.05	4.25	3.70	3.60
7	3.80	4.35	5.05	4.20	3.90	2.80	23	4.60	4.80	4.95	4.05	3.70	3.50
8	3.85	4.30	5.00	4.10	3.95	2.80	24	4.58	4.65	4.80	4.10	3.35	3.50
9	3.95	4.35	5.15	4.25	3.80	2.80	25	4.75	4.95	4.80	4.10	3.85	3.55
10	4.25	4.40	5.45	4.20	3.90	2.75	26	4.70	5.00	5.00	4.20	3.85	3.55
11	4.15	4.70	5.40	4.35	4.00	2.80	27	4.68	5.10	4.90	4.35	3.60	3.50
12	4.25	4.65	5.45	4.45	4.00	2.85	28	4.55	5.10	4.85	4.00	3.45	3.50
13	4.30	4.90	5.85	4.50	3.95	2.90	29	4.45	5.10	4.85	4.10	3.40	3.45
14	4.35	5.10	5.75	4.50	3.95	3.85	30	4.30	5.35	4.70	4.15	3.30	3.45
15	4.40	5.15	5.85	4.35	3.95	3.95	31	.....	5.35	.....	4.05	3.20	.....
16	4.55	5.25	5.55	4.40	3.85	3.70							

Closed for the winter September 30.

GUNNISON RIVER AT GRAND JUNCTION, COLORADO.

his river, the principal tributary of Grand River, has its source the western slope of the Continental Divide in south-central Colo-o, and flows in a general westerly direction into Grand River at ınd Junction. There were two gaging stations maintained within basin during the last season, one at Fort Crawford, on the Uncom-gre, and the other at Grand Junction, at the mouth of Gunnison 'er. This latter station was established in May, 1897, and is ıted at the iron highway bridge one and one-half miles from the 'n of Grand Junction. The gage is vertical and consists of a timber ted to the stone pier of the bridge. The bench mark is the top of capstone of the bridge pier, and is 17.60 feet above gage datum. e measurements here are not satisfactory, owing to the fact that at h stages of Grand River the water backs up the mouth of the Gun-on considerably above the point where the gage rod upon the er is located, thus affecting the gage readings so seriously that no sfactory rating table can be made for this point. The station will be resumed the coming year. Results of measurements may be nd as follows: 1897, Nineteenth Annual Report, Part IV, page

405; 1898, Twentieth Annual Report, Part IV, page 390. The following measurements of discharge were made by A. L. Fellows during 1899:

April 15, gage height, 3.50 feet; discharge, 3,002 second-feet.
May 13, gage height, 7 feet; discharge, 14,280 second-feet.
June 18, gage height, 7.15 feet; discharge, 12,769 second-feet.
September 19, gage height, 2.20 feet; discharge, 1,061 second-feet.
November 18, gage height, 2 feet; discharge, 968 second-feet.

Daily gage height, in feet, of Gunnison River at Grand Junction, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1....	2.00	4.60	6.60	5.60	3.00	1.80	17.....	3.90	7.30	7.20	3.80	2.70	1.80
2....	2.10	4.50	6.50	5.40	4.30	1.90	18.....	4.20	7.00	7.10	3.80	2.60	1.90
3....	2.00	4.40	6.40	5.60	3.10	1.80	19.....	4.30	7.10	7.20	3.70	2.60	2.10
4....	2.00	4.00	6.00	5.60	3.80	1.90	20.....	4.50	7.30	7.30	3.90	2.50	2.00
5....	2.00	4.00	5.60	5.40	4.00	1.90	21.....	4.20	7.00	7.20	3.80	2.40	1.80
6....	2.00	4.00	5.50	5.00	3.60	1.90	22.....	3.90	6.50	7.10	3.70	2.40	1.60
7....	2.10	4.10	5.50	4.90	3.40	2.00	23.....	4.20	5.80	6.80	3.60	2.20	1.60
8....	2.10	4.30	5.80	4.20	3.30	1.90	24.....	4.70	5.90	6.50	3.50	2.10	1.60
9....	2.20	4.80	5.90	4.20	3.20	1.60	25.....	5.00	6.20	6.40	3.30	2.00	1.60
10....	2.30	5.20	6.00	4.10	3.20	1.50	26.....	5.40	6.40	6.40	3.20	1.80	1.60
11....	2.60	5.80	6.50	4.00	3.00	1.50	27.....	5.70	6.50	6.50	3.00	1.80	1.40
12....	2.80	6.30	6.90	3.90	2.70	1.40	28.....	5.60	6.70	6.10	3.30	1.80	1.40
13....	3.00	6.60	7.30	3.90	2.70	1.40	29.....	5.40	6.50	5.80	3.60	1.80	1.40
14....	3.40	7.20	7.50	4.00	2.70	1.60	30.....	5.00	6.40	5.70	3.30	1.80	1.30
15....	3.60	7.40	7.50	4.00	2.70	1.80	31.....	.....	6.60	.....	3.20	2.10	.....
16....	3.70	7.50	7.40	3.90	2.70	1.80							

Station discontinued September 30.

[Continued in Water-Supply and Irrigation Paper No. 38.]

O

1895.

Fifteenth Annual Report of the United States Geological Survey, 1894-95, Part II, Papers of an economic character, 1895; octavo, 595 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnaissance of northwestern Wyoming, by George H. Eldridge, 1894; octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Bighorn Range and Bighorn Basin, especially with reference to the coal fields and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar years 1893 and 1894, by F. H. Newell, 1895; octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895-96, Part II, Economic geology and hydrography, 1896; octavo, 864 pp.

Contains papers on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett, and "Preliminary report on the artesian areas of a portion of the Dakotas," by N. H. Darton.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 356 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896-97, Part IV, Hydrography, 1897; octavo, 756 pp.

Contains a "Report of progress of stream measurements for the year 1896," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "New developments in well boring and irrigation in South Dakota," by N. H. Darton, and "Reservoirs for irrigation," by J. D. Schuyler.

1899.

Nineteenth Annual Report of the United States Geological Survey, 1897-98, Part IV, Hydrography, 1899; octavo, 814 pp.

Contains a "Report of progress of stream measurements for the calendar year 1897," by F. H. Newell and others; "The rock waters of Ohio," by Edward Orton, and "Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian," by N. H. Darton.

1900.

Twentieth Annual Report of the United States Geological Survey, 1898-99, Part IV, Hydrography, 1900; octavo, 666 pp.

Contains a "Report of progress of stream measurements for the calendar year 1898," by F. H. Newell, and "Hydrography of Nicaragua," by A. P. Davis.

WATER-SUPPLY AND IRRIGATION PAPERS, 1896-1900.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost, as noted above. Postage stamps, checks, and drafts can not be accepted. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Correspondence relating to the publications of the Survey should be addressed to **The Director, United States Geological Survey, Washington, D. C.**

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phoenix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnaissance in southeastern Washington, by Israel C. Russell, 189
5. Irrigation practice on the Great Plains, by R. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897.
7. Seepage waters of northern Utah, by Samuel Fortier, 1897.
8. Windmills for irrigation, by E. C. Murphy, 1897.
9. Irrigation near Greeley, Colorado, by David Boyd, 1897.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker, 1898.
11. River heights for 1896, by Arthur P. Davis, 1897.
12. Underground waters of southeastern Nebraska, by N. H. Darton, 1898.
13. Irrigation systems in Texas, by W. F. Hutson, 1898.
14. New tests of pumps and water lifts used in irrigation, by O. P. Hood, 18
15. Operations at river stations, 1897, Part I, 1898.
16. Operations at river stations, 1897, Part II, 1898.
17. Irrigation near Bakersfield, California, by C. E. Grunsky, 1898.
18. Irrigation near Fresno, California, by C. E. Grunsky, 1898.
19. Irrigation near Merced, California, by C. E. Grunsky, 1899.
20. Experiments with windmills, by Thomas O. Perry, 1899.
21. Wells of northern Indiana, by Frank Leverett, 1899.
22. Sewage irrigation, Part II, by George W. Rafter, 1899.
23. Water-right problems of Bighorn Mountains, by Elwood Mead, 1899.
24. Water resources of the State of New York, Part I, by George W. Rafter, 18
25. Water resources of the State of New York, Part II, by George W. Rafter, 18
26. Wells of southern Indiana (continuation of No. 21), by Frank Leverett 18
27. Operations at river stations, 1898, Part I, 1899.
28. Operations at river stations, 1898, Part II, 1899.
29. Wells and windmills in Nebraska, by Erwin Hinckley Barbour, 1899.
30. Water resources of the Lower Peninsula of Michigan, by Alfred C. Lane, 18
31. Lower Michigan mineral waters, by Alfred C. Lane, 1899.
32. Water resources of Puerto Rico, by H. M. Wilson, 1900.
33. Storage of water on Gila River, Arizona, by J. B. Lippincott, 1900.
34. Geology and water resources of southeastern S. Dak., by J. E. Todd, 1900
35. Operations at river stations, 1899, Part I, 1900.
36. Operations at river stations, 1899, Part II, 1900.
37. Operations at river stations, 1899, Part III, 1900.
38. Operations at river stations, 1899, Part IV, 1900.
39. Operations at river stations, 1899, Part V, 1900.

In addition to the above, there are in various stages of preparation other pap relating to the measurement of streams, the storage of water, the amount availa from underground sources, the efficiency of windmills, the cost of pumping, a other details relating to the methods of utilizing the water resources of the co try. Provision has been made for printing these by the following clause in t sundry civil act making appropriations for the year 1896–97:

Provided, That hereafter the reports of the Geological Survey in relation to t gaging of streams and to the methods of utilizing the water resources may printed in octavo form, not to exceed 100 pages in length and 5,000 copies in nu ber; 1,000 copies of which shall be for the official use of the Geological Surv 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered the House of Representatives, for distribution. [Approved June 11, 1896; Stat. vol. 29, p. 453.]

The maximum number of copies available for the use of the Geological Surv is 1,000. This quantity falls far short of the demand, so that it is impossible supply all requests. Attempts are made to send these pamphlets to persons w have rendered assistance in their preparation through replies to schedules or w have furnished data. Requests made for a certain paper and stating a reason asking for it are granted whenever practicable, but it is impossible to com with general demands, such as to have all of the series sent indiscriminately.

Application for these papers should be made either to Members of Congress or

THE DIRECTOR, UNITED STATES GEOLOGICAL SURVEY, WASHINGTON, D. C

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 38

OPERATIONS AT RIVER STATIONS, 1899.—PART IV

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

IRRIGATION REPORTS.

The following list contains titles and brief descriptions of the principal relating to water supply and irrigation, prepared by the United States G Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 1

Printed as Part II, Irrigation, of the Tenth Annual Report of the United Stat ical Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, a p report on the organization and prosecution of the survey of the arid lands for purpo gation, and report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo

Published as Part II, Irrigation, of the Eleventh Annual Report of the United Stat ical Survey, 1889-90. Contains a description of the hydrography of the arid region engineering operations carried on by the Irrigation Survey during 1890; also the st the Director of the Survey to the House Committee on Irrigation, and other papers, i bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891; octavo,

Printed as Part II of the Twelfth Annual Report of the United States Geologic 1890-91. Contains "Report upon the location and survey of reservoir sites during year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid regions," Newell; "Irrigation in India," by Herbert M. Wilson. Illustrated by 93 plates and 1

Bulletins of the Eleventh Census of the United States upon irrigation, pre F. H. Newell; quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. gation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrig Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Ir in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulleti September 9, 1892; quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated ho total area and average size of irrigated farms in the subhumid regions the percentag ber of farms irrigated, character of crops, value of irrigated lands, the average cost of the investment and profits, together with a resumé of the water supply and a descript gation by artesian wells. Illustrated by colored maps, showing the location and relativ the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-III, Irrigation, 1893; octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell, "Amer tion engineering" and "Engineering results of the Irrigation Survey" by Herbert M "Construction of topographic maps and selection and survey of reservoir sites," Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russ octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States G Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adja drainage basin of Yakima River and the great plains of the Columbia to the east of with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United Stat Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States irrigated, cost of works, their value and profits; also describes the water supply, t water, of artesian wells, reservoirs, and other details; then takes up each State and T order, giving a general description of the condition of agriculture by irrigation, and the physical conditions and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892-9 parts; Part II, Accompanying papers, 1894; octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W J McGee ral mineral waters of the United States," by A. C. Peale; "Results of stream measu by F. H. Newell. Illustrated by maps and diagrams

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

RRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 38

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

OPERATIONS AT RIVER STATIONS, 1899

A REPORT OF THE

DIVISION OF HYDROGRAPHY

OF THE

UNITED STATES GEOLOGICAL SURVEY

PART IV

WASHINGTON
GOVERNMENT PRINTING OFFICE
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PERATIONS AT RIVER STATIONS, 1899.

PART IV.

MEASUREMENTS AT RIVER STATIONS.[1]

DOLORES RIVER AT DOLORES, COLORADO.

is river is the last important tributary of Grand River. It has urce in the La Plata and San Miguel mountains, in which the st peak, Mount Wilson, attains an elevation of 14,280 feet. Its e is in a general northwesterly direction. Crossing into Utah it ly joins Grand River. In the vicinity of Dolores considerable ation is practiced, both from small ditches and from one or two systems. The main canal of the Montezuma Valley irrigation m diverts water from the left bank of the river a short distance r the gaging station, and after crossing the divide between the res and San Juan drainage irrigates land in the vicinity of Cortez. ver lateral of this system serves land to the northwest of Dolores. gaging station is located one-half mile above the railroad station lores, Colorado. The gage rod consists of a vertical plank bolted e abutment of a footbridge on the left side of the river. The l mark consists of a nail driven into the base of a cottonwood 18 feet southwesterly from the gage, and is 15.60 feet above gage n. The right bank is low and the left bank high; the water moves a good velocity; the bed of the stream is composed of small s and gravel. Dolores River at Rico, Colorado, was measured times during the year: April 19 the discharge was 168 second- September 22, 23 second-feet, and November 22, 16 second-feet. lts of measurements at this station may be found as follows: Eighteenth Annual Report, Part IV, page 263; 1897, Nineteenth al Report, Part IV, page 408; 1898, Twentieth Annual Report, IV, page 393. The following discharge measurements were by A. L. Fellows during 1899:

April 20, gage height, 3.60 feet; discharge, 613 second-feet.
May 17, gage height, 4.15 feet; discharge, 963 second-feet.
June 22, gage height, 3.30 feet; discharge, 307 second-feet.
November 22, gage height, 2.70 feet; discharge, 56 second-feet.

[1] Continued from Water-Supply and Irrigation Paper No. 37.

Daily gage height, in feet, of Dolores River at Dolores, Colorado, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.60	3.05	3.75	3.10	2.95	2.65	2.50	2.80	2.55
2	.....	2.70	2.90	3.75	3.15	2.95	2.60	2.50	2.80	2.55
3	.....	2.70	3.15	3.55	3.25	3.50	2.60	2.50	2.70	2.55
4	.....	2.85	3.15	3.40	3.10	3.85	2.60	2.60	2.70	2.55
5	.....	2.85	3.80	3.40	3.10	3.60	2.50	2.60	2.70	2.75
6	.....	2.85	3.45	3.40	3.10	3.30	2.50	2.60	2.70	2.95
7	.....	2.95	3.70	3.65	3.10	3.70	2.50	2.50	2.70	3.00
8	.....	2.95	3.70	3.75	3.10	3.40	2.50	2.50	2.60	3.10
9	.....	3.05	3.60	3.85	3.00	3.25	2.50	2.50	2.60	3.10
10	.....	3.05	3.90	3.95	2.90	3.05	2.50	2.50	2.60	3.10
11	.....	3.20	4.10	3.90	2.90	3.00	2.50	2.50	2.60	3.10
12	.....	3.35	4.35	3.90	3.00	2.95	2.50	3.10	2.60	3.00
13	.....	3.25	4.65	3.85	3.15	2.90	2.50	3.30	2.60	3.00
14	.....	3.40	4.75	3.85	3.15	2.90	2.55	3.25	2.65	3.00
15	.....	3.60	4.75	3.70	3.10	2.95	2.80	3.00	2.70	3.00
16	.....	3.60	4.55	3.60	3.10	3.15	2.80	3.00	2.70	3.00
17	.....	3.60	4.15	3.50	3.10	3.15	2.70	3.00	2.70	3.05
18	.....	3.70	4.20	3.50	3.20	3.20	2.70	3.00	2.60	3.05
19	.....	4.05	4.40	3.50	3.40	3.05	2.65	3.00	2.60	3.05
20	.....	3.65	4.05	3.40	3.15	2.90	2.60	2.95	2.60	3.00
21	.....	3.55	3.60	3.30	3.10	2.90	2.60	2.85	2.60	3.00
22	2.40	3.85	3.70	3.30	3.00	2.85	2.55	2.80	2.60	3.00
23	2.40	3.90	3.85	3.25	3.00	2.75	2.50	2.80	2.70	3.00
24	2.40	4.00	4.15	3.20	2.95	2.70	2.50	2.75	2.70	2.95
25	2.50	4.05	4.00	3.20	2.90	2.70	2.50	2.70	2.70	2.95
26	2.80	4.00	4.00	3.25	2.85	2.60	2.50	2.70	2.70	2.90
27	2.55	3.90	3.85	3.40	2.90	2.60	2.50	2.70	2.65	3.00
28	2.75	3.75	3.80	3.25	2.90	2.60	2.50	2.70	2.65	3.00
29	2.60	3.55	3.80	3.10	3.00	2.60	2.50	2.70	2.65	3.00
30	2.65	3.20	3.85	3.10	3.25	2.60	2.50	2.70	2.65	3.00
31	2.50	.....	3.85	.....	3.15	2.55	.....	2.80	.....	3.05

SAN MIGUEL RIVER AT FALLCREEK, COLORADO.

This river has its source in the high mountain peaks in the southwestern corner of San Miguel County, and drains an area immediately to the westward of the head waters of Uncompahgre River. The general direction of the river is northeasterly, and it enters Dolores River in the western part of Montrose County, Colorado. The station, established in June, 1895, is located about 300 yards southwest of Fallcreek, a railroad station on the Rio Grande Southern Railroad. The gage is vertical and spiked to the west side of the north abutment of the wagon bridge. Bench mark No. 1 is a bolthead in the north end of the west truss, 1 foot from the gage, and is 11.15 feet above gage datum. Bench mark No. 2 is a spike driven into a tree 200 feet northwest of the rod, and is 8.65 feet above gage datum. Fall Creek enters the San Miguel about 200 feet below the gage. On May 16, 1899, it was found to be carrying 62 second-feet, and on June 21, 45 second-feet. The results of measurements on the main river may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 265; 1897, Nineteenth Annual Report, Part IV, page 407; 1898, Twentieth Annual Report, Part IV, page 395. The following measurements of discharge were made by A. L. Fellows during 1899:

April 18, gage height, 2.85 feet; discharge, 164 second-feet.
May 16, gage height, 3.70 feet; discharge, 562 second-feet.
June 21, gage height, 3.60 feet; discharge, 449 second-feet.
November 21, gage height, 2.35 feet; discharge, 52 second-feet.

Daily gage height, in feet, of San Miguel River at Fallcreek, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1....	2.30	2.80	3.50	3.35	2.90	2.60	17.....	2.85	3.65	3.85	3.00	2.90	2.60
2....	2.20	2.75	3.45	3.50	3.20	2.60	18.....	2.90	3.80	3.85	3.35	2.90	2.60
3....	2.30	2.75	3.40	3.40	3.50	2.65	19.....	2.95	3.70	3.90	3.25	3.00	2.60
4....	2.30	2.70	3.30	3.30	3.35	2.65	20.....	2.95	3.60	3.80	3.05	2.85	2.55
5....	2.25	2.80	3.15	3.20	3.35	2.55	21.....	2.80	3.30	3.75	3.00	2.75	2.60
6....	2.30	2.80	3.25	3.10	3.35	2.60	22.....	2.85	3.20	3.70	3.00	2.70	2.60
7....	2.30	3.00	3.25	3.05	3.35	2.60	23.....	3.20	3.40	3.45	2.95	2.70	2.50
8....	2.40	3.00	3.30	3.00	3.25	2.60	24.....	3.20	3.50	3.35	2.95	2.80	2.60
9....	2.40	3.00	3.75	3.00	3.15	2.60	25.....	3.30	3.55	3.30	3.00	2.70	2.60
10....	2.50	3.20	4.05	3.05	3.00	2.60	26.....	3.20	3.50	3.35	2.95	2.65	2.60
11....	2.45	3.40	4.05	3.05	2.90	2.55	27.....	3.05	3.55	3.30	3.00	2.60	2.60
12....	2.50	3.75	3.95	3.15	3.00	2.40	28.....	2.90	3.55	3.30	3.00	2.60	2.60
13....	2.70	3.95	3.90	3.20	3.00	2.40	29.....	2.80	3.55	3.35	3.10	2.60	2.50
14....	2.70	4.00	4.00	3.25	3.00	2.70	30.....	2.90	3.80	3.30	3.00	2.60	2.40
15....	2.80	3.90	4.00	3.10	3.00	2.75	31.....	.....	3.80	.....	2.90	2.60	.....
16....	2.75	3.80	3.90	3.00	2.95	2.65							

Station discontinued September 30.

SAN JUAN RIVER AT ARBOLES, COLORADO.

his river has its source on the western slope of the Continental ride in southern Colorado, its headwater tributaries adjoining those the Rio Grande. Its general direction is southwesterly, but after eceives the waters of Piedra River and crosses the State line into v Mexico, it takes a more westerly direction for some distance, n turns northwest, passing very close to the four corners of Utah, orado, New Mexico, and Arizona. After flowing for a considerable ance through a canyon country in Utah, it enters Colorado River a rt distance above Marble Canyon. The gaging station, established e 19, 1895, is located at the town of Arboles, at a footbridge ut 1,000 feet below the Rio Grande Southern railroad station and ve the mouth of Piedra River. The rod is an inclined timber ked to vertical tenths of a foot, the space between marks being 1 foot, and is bolted to the rocky bank on the right-hand side of stream. The left bank is low and liable to overflow at high stages. bed is sandy and shifting. The results of measurements may be nd as follows: 1896, Eighteenth Annual Report, Part IV, page 281; 7, Nineteenth Annual Report, Part IV, page 410; 1898, Twentieth nual Report, Part IV, page 401. The following measurements of harge were made by A. L. Fellows during 1899:

April 23, gage height, 7 feet; discharge, 1,286 second-feet.
May 22, gage height, 6.60 feet; discharge, 737 second-feet.
June 26, gage height, 6.15 feet; discharge, 277 second-feet.
November 26, gage height, 5.75 feet; discharge, 127 second-feet.

Daily gage height, in feet of San Juan River at Arboles, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	6.40	6.65	6.05	6.25	5.70	17	.....	6.85	6.35	6.60	6.10	6.20
2	.....	6.35	6.55	6.00	6.15	5.70	18	.....	6.85	6.35	7.25	6.15	6.10
3	.....	6.30	6.55	6.05	7.25	5.70	19	.....	7.00	6.30	7.40	5.95	6.00
4	.....	6.30	6.50	6.00	7.30	5.70	20	.....	6.85	6.25	7.25	5.90	6.00
5	.....	6.30	6.50	6.05	6.95	5.70	21	.....	6.60	6.30	7.10	5.85	6.00
6	.....	6.25	6.50	5.95	6.60	5.65	22	.....	6.55	6.35	6.70	5.80	5.90
7	.....	6.35	6.55	6.25	6.65	5.60	23	7.00	6.75	6.30	6.40	5.85	5.85
8	.....	6.45	6.65	6.20	6.55	5.60	24	6.95	6.85	6.20	6.35	5.85	5.80
9	.....	6.40	6.60	6.10	6.35	5.70	25	6.90	6.85	6.20	6.20	5.80	5.80
10	.....	6.50	6.65	6.00	6.30	5.70	26	6.80	6.80	6.25	6.15	5.80	5.80
11	.....	6.80	6.65	5.95	6.20	5.70	27	6.75	6.85	6.35	6.20	5.80	5.70
12	.....	7.10	6.60	5.85	6.05	5.70	28	6.55	6.75	6.20	6.30	5.70	5.70
13	.....	7.50	6.55	5.90	5.95	5.60	29	6.50	6.65	6.10	6.60	5.70	5.70
14	.....	7.30	6.50	5.85	5.90	5.65	30	6.45	6.65	6.15	6.70	5.70	5.70
15	.....	7.25	6.50	5.95	5.90	7.40	31	.....	6.75	.....	6.55	5.70	.....
16	.....	7.00	6.45	6.00	5.95	6.65							

Station discontinued September 30.

PIEDRA RIVER AT ARBOLES, COLORADO.

This tributary of San Juan River has its source in Hinsdale and Mineral counties in southern Colorado, and flows in a general southerly direction, entering San Juan River just before the latter crosses into New Mexico. The station, established June 19, 1895, is located at the railroad bridge crossing Piedra River about one-half mile west of the railroad station at Arboles. The gage is bolted to the stone abutment of the railroad bridge on the right-hand side of the stream, and consists of a vertical 4 by 4 inch timber. The bench mark is a cross cut in the top of abutment in the southeast corner of bridge 402–A, and is 14.88 feet above gage datum. The banks are both high, the current is swift, and the bed is composed of small stones. The cross section does not change materially. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 283; 1897, Nineteenth Annual Report, Part IV, page 413; 1898, Twentieth Annual Report, Part IV, page 402. The following measurements were made by A. L. Fellows during 1899:

April 23, gage height, 3.80 feet; discharge, 499 second-feet.
May 22, gage height, 3.40 feet; discharge, 279 second-feet.
June 26, gage height, 2.90 feet; discharge, 111 second-feet.
November 26, gage height, 2.80 feet; discharge, 88 second-feet.

Daily gage height, in feet, of Piedra River at Arboles, Colorado, for 1899.

.	Apr.	May.	June.	July.	Aug.	Sept.	Day.	Apr.	May.	June.	July.	Aug.	Sept.
...	.....	3.25	3.30	2.85	3.05	2.50	17.....	.....	3.75	3.00	2.90	2.85	2.90
...	.....	3.20	3.20	2.85	3.00	2.50	18.....	.....	3.65	2.95	3.10	2.80	2.80
...	.....	3.05	3.25	3.00	4.05	2.50	19.....	.....	3.75	2.90	3.75	2.80	2.70
...	.....	3.00	3.20	2.95	4.45	2.50	20.....	.....	3.55	2.90	3.55	2.80	2.60
...	.....	3.00	3.15	2.90	3.75	2.50	21.....	.....	3.35	2.90	3.45	2.75	2.50
...	.....	3.05	3.20	2.80	3.75	2.50	22.....	.....	3.40	2.90	3.20	2.70	2.50
...	.....	3.10	3.30	3.05	3.60	2.40	23.....	3.80	3.35	2.95	3.00	2.70	2.50
...	.....	3.20	3.35	2.95	3.50	2.40	24.....	3.75	3.45	2.80	2.90	2.70	2.50
...	.....	3.25	3.35	2.95	3.35	2.50	25.....	3.75	3.50	2.80	2.80	2.70	2.50
...	.....	3.30	3.35	2.80	3.20	2.60	26.....	3.70	3.40	2.85	2.80	2.70	2.50
...	.....	3.65	3.30	2.85	3.15	2.60	27.....	3.65	3.45	3.25	2.75	2.65	2.50
...	.....	4.05	3.25	2.65	3.00	2.50	28.....	3.55	3.45	3.05	2.80	2.60	2.50
...	.....	4.10	3.15	2.75	2.90	2.50	29.....	3.45	3.30	2.90	3.05	2.60	2.45
...	.....	3.95	3.10	2.80	2.90	2.55	30.....	3.35	3.35	2.85	3.20	2.50	2.40
...	.....	4.05	3.10	2.85	2.90	2.95	31.....	.....	3.30	.....	3.15	2.50	.....
...	.....	3.90	3.05	2.85	2.90	3.00							

Station discontinued September 30.

LOS PINOS RIVER AT IGNACIO, COLORADO.

stream heads in the high mountains of San Juan County in western Colorado, and flows in a nearly southerly direction, g the State line into New Mexico and emptying into San Juan

The station was established by A. L. Fellows on April 22, nd is located at the wagon bridge at Ignacio, the subagency of uthern Ute Indian Reservation, 2 miles north of the Denver and ande railroad station. The rod is a vertical 2 by 4 inch timber, t long, spiked to the bridge, the marks being strips of brass ly nailed to the post. There is one bench mark, the 8-foot on the gage rod, which is level with the top of the lower end of 8 inch timber protruding downstream from the pier on the and side. The banks are low, but not subject to overflow; the the stream is of gravel, but not liable to radical change. The er is the clerk at the agency. The following measurements ade by A. L. Fellows during 1899:

April 22, gage height, 3.20 feet; discharge, 437 second-feet.
May 20, gage height, 3.40 feet; discharge, 577 second-feet.
June 25, gage height, 2.80 feet; discharge, 244 second-feet.
November 25, gage height, 2.60 feet; discharge, 124 second-feet.

Daily gage height, in feet, of Los Pinos River at Ignacio, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	De
1	.....	2.90	3.35	2.95	3.05	2.30	2.30	2.50	2.
2	.....	2.90	3.25	2.95	3.40	2.30	2.25	2.50	2.
3	.....	2.80	3.15	2.95	4.05	2.30	2.20	2.50	2.
4	.....	2.80	3.10	2.95	4.75	2.20	2.45	2.50	2.
5	.....	2.75	3.00	2.80	3.90	2.25	2.50	2.50	2.
6	.....	2.70	3.05	2.80	3.60	2.20	2.40	2.50	2.
7	.....	2.70	3.15	2.80	3.55	2.20	2.40	2.50	2.
8	.....	2.85	3.30	2.80	3.50	2.25	2.30	2.50	2.
9	.....	2.90	3.35	2.75	3.35	2.25	2.30	2.50	2.
10	.....	3.05	3.35	2.70	3.20	2.25	2.30	2.50	2.
11	.....	3.35	3.40	2.70	3.00	2.20	2.25	2.50	2.
12	.....	3.85	3.45	2.65	2.95	2.30	2.55	2.50	2.
13	.....	4.05	3.40	2.60	2.90	2.30	2.70	2.50	2.
14	.....	3.95	3.45	2.70	2.85	2.30	2.90	2.50	2.
15	.....	3.85	3.45	2.70	2.80	2.85	2.85	2.60	2.
16	.....	3.75	3.35	2.70	2.90	2.65	2.80	2.60	2.
17	.....	3.60	3.25	2.70	2.90	2.45	2.80	2.60	2.
18	.....	3.60	3.20	2.80	2.90	2.40	2.70	2.60	2.
19	.....	3.80	3.20	3.55	2.85	2.40	2.70	2.60	2.
20	.....	3.50	3.15	3.30	2.75	2.40	2.70	2.60	2.
21	.....	3.25	3.10	3.10	2.65	2.40	2.70	2.60	2.
22	.....	3.20	3.05	3.05	2.60	2.40	2.70	2.60	Ic
23	3.40	3.30	2.95	2.95	2.55	2.40	2.70	2.60	Ic
24	3.50	3.55	2.90	2.85	2.50	2.30	2.70	2.60	Ic
25	3.50	3.55	2.85	2.80	2.45	2.30	2.65	2.60	Ic
26	3.40	3.35	3.25	2.80	2.40	2.30	2.60	2.60	Ic
27	3.20	3.35	3.45	2.80	2.40	2.30	2.60	2.50	Ic
28	3.20	3.30	3.25	2.80	2.40	2.30	2.50	2.50	Ic
29	3.00	3.35	3.15	3.15	2.35	2.30	2.50	2.50	Ic
30	2.90	3.35	3.05	3.35	2.30	2.30	2.50	2.50	Ic
31	.....	3.45	.....	3.20	2.30	.....	2.50	.....	Ic

ANIMAS RIVER AT DURANGO, COLORADO.

This river is an important tributary of the San Juan, and h source in the high peaks of southwestern Colorado. It has a n southerly course, crossing the State line into New Mexico, whe shortly enters San Juan River. The station originally established 20, 1895, was located at the wagon bridge one-quarter of a mile w the railroad station at Durango, and about 200 feet above the Rio G Southern railroad bridge. During the early part of the year th wagon bridge was removed and a new one erected a short dis below. April 1, 1899, a gage rod was placed on the central pier o new bridge. The bench marks are three horizontal strips, opposit 10-, 14-, and 16.7-foot marks of the rod, respectively. Owing t change in location and height of the rod there is no apparent rel between the rating tables for past years and the rating table for Lightner Creek enters Animas River from the right about 10 below the wagon bridge. The channel is straight both above below the station, and the bed is of gravel and fairly permanent. results of measurements may be found as follows: 1896, Eight Annual Report, Part IV, page 285; 1897, Nineteenth Annual Re Part IV, page 414; 1898, Twentieth Annual Report, Part IV, 403. Measurements for 1899 were made by A. L. Fellows, as fol

April 21, gage height, 7.50 feet; discharge, 698 second-feet.
May 19, gage height, 9.45 feet; discharge, 2,635 second-feet.
June 24, gage height, 8.10 feet; discharge, 1,256 second-feet.
September 28, gage height, 6.52 feet; discharge, 223 second-feet.
November 25, gage height, 6.50 feet; discharge, 201 second-feet.

Daily gage height, in feet, of Animas River at Durango, Colorado, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	6.45	7.40	9.20	7.80	7.05	6.85	6.50	6.80	.....
2	6.50	7.35	8.75	7.85	7.25	6.80	.....	.....	6.40
3	6.45	7.35	8.35	8.05	8.20	6.80	.....	.....	.....
4	6.35	7.35	8.05	7.75	8.90	6.75	.....	6.70	6.40
5	6.35	7.35	7.75	7.65	8.45	6.70	.....	.....	.....
6	6.30	7.25	7.90	7.60	8.15	6.70	.....	.....	.....
7	6.35	7.25	8.20	7.65	8.15	6.65	6.50	6.80	.....
8	6.40	7.50	8.45	7.50	8.00	6.70	.....	.....	.....
9	6.45	7.65	8.70	7.45	7.70	6.70	.....	.....	6.40
10	6.50	7.80	9.15	7.45	7.55	6.65	.....	6.70	.....
11	6.70	8.60	9.30	7.30	7.45	6.60	6.80	.....	.....
12	6.80	9.40	9.60	7.35	7.35	6.60	.....	.....	6.50
13	7.00	9.85	9.65	7.40	7.30	6.60	.....	.....	.....
14	7.10	10.00	9.55	7.40	7.20	6.60	6.90	6.70	.....
15	7.30	9.80	9.45	7.40	7.20	6.90	.....	.....	.....
16	7.55	9.60	9.25	7.35	7.35	6.95	.....	.....	6.70
17	7.50	9.50	9.15	7.20	7.55	6.90	6.80	.....	.....
18	7.65	9.35	9.10	7.25	7.45	6.80	.....	6.70	.....
19	7.75	9.40	8.85	7.90	7.30	6.80	.....	.....	.....
20	7.65	9.05	8.75	7.75	7.25	6.75	.....	.....	.....
21	7.45	8.20	8.65	7.45	7.20	6.70	6.80	6.70	.....
22	7.55	8.05	8.55	7.35	7.10	6.70	.....	.....	6.60
23	7.95	8.10	8.35	7.30	7.05	6.70	.....	.....	.....
24	8.05	8.90	8.10	7.20	7.00	6.60	6.90	.....	.....
25	8.10	9.00	8.00	7.15	6.95	6.60	.....	6.50	.....
26	8.00	8.80	8.25	7.10	6.90	6.60	.....	.....	6.70
27	7.95	8.90	8.25	7.10	6.90	6.60	.....	.....	.....
28	7.85	8.50	8.00	7.00	6.85	6.60	6.80	.....	.....
29	7.65	8.80	7.95	7.00	6.80	6.55	.....	6.50	6.50
30	7.45	9.30	7.80	7.20	6.80	6.50	.....	.....	.....
31	.....	9.35	.....	7.15	6.80	.....	.....	.....	.....

FLORIDA RIVER NEAR DURANGO, COLORADO.

is stream is a tributary of Animas River, and rises in the north-part of La Plata County; flowing in a general southerly direction ters Animas River a short distance before this latter stream passes New Mexico. During the last season work has been prosecuted on ge storage project near the head of the river, and on this account a ng station was established by A. L. Fellows May 19, 1899. It is ed at a wagon bridge at Stewart's ranch, 9 miles east of Durango. gage rod consists of a vertical 2 by 4 inch timber fastened to the nstream side of the left-hand abutment of the bridge. In 1899 measurements of discharge were made at this point by A. L. ows. The first, on May 19, at a gage height of 2.25 feet, showed charge of 236 second-feet; the second, on June 24, at a gage height .70 feet, showed a discharge of 9 second-feet.

Daily gage height, in feet, of Florida River near Durango, Colorado, for 1899.

ay.	May.	June.	July.	Day.	May.	June.	July.	Day.	May.	June.	July.
1	.....	1.65	1.05	12	.....	1.70	0.65	23	1.90	0.75	1.00
2	.....	1.50	.95	13	.....	1.60	.70	24	2.05	.75	.95
3	.....	1.35	1.05	14	.....	1.60	.85	25	2.00	.75	.80
4	.....	1.25	.95	15	.....	1.45	.65	26	1.80	1.25	.95
5	.....	1.20	.95	16	.....	1.30	.65	27	1.80	1.60	1.10
6	.....	1.40	.90	17	.....	1.25	.70	28	1.65	1.35	1.25
7	.....	1.60	.65	18	.....	1.15	1.60	29	1.75	1.10	2.15
8	.....	1.70	.75	19	.....	1.15	1.85	30	1.70	1.00	1.90
9	.....	1.70	.70	20	.....	1.05	1.45	31	1.80	.....	1.60
0	.....	1.60	.75	21	1.65	1.00	1.25				
1	.....	1.55	.65	22	1.60	.95	1.05				

Station discontinued July 31.

MANCOS RIVER AT MANCOS, COLORADO.

This river is an important tributary of the San Juan, southwestern corner of Colorado. The lower portion of through the Southern Ute Indian Reservation. It ente River near the adjoining corners of Utah, Colorado, New Arizona. The primary object of a station on this river w data relative to the amount of water that can be stored f supply of the Southern Ute Indian Reservation. The re investigation, made by Mr. G. H. Matthes, may be found tieth Annual Report, Part IV, pages 408 to 434. The ga established by A. L. Fellows April 9, 1898, is located 10 the wagon bridge across the river in the center of the tow The gage consists of a vertical timber spiked to a cotton the left bank of the river. Measurements are usually mad but the wagon bridge can be used at high stages of banks are not subject to overflow. The channel is in grav liable to radical change. The results of measurements in found in the Twentieth Annual Report, Part IV, pag following measurements of discharge were made by A during 1899:

April 19, gage height, 1.65 feet; discharge, 70 second-fee
May 18, gage height, 1.60 feet; discharge, 56 second-feet
June 23, gage height, 1.10 feet; discharge, 9 second-feet
September 22, gage height, 0.90 foot; discharge, 2 secon
November 24, gage height, 1 foot; discharge, 3 second-f

Daily gage height, in feet, of Mancos River at Mancos, Colorado,

Day.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	1.50	1.70	1.10	1.20	1.00
2	.....	1.40	1.70	1.00	1.20	1.00
3	.....	1.40	1.70	1.10	1.40	1.00
4	.....	1.40	1.60	1.10	1.60	1.00
5	.....	1.30	1.50	1.10	1.60	1.00
6	.....	1.40	1.50	1.10	1.70	1.00
7	.....	1.40	1.50	1.10	1.50	1.00
8	.....	1.40	1.50	1.10	1.60	1.00
9	1.00	1.50	1.60	1.00	1.60	1.00
10	1.10	1.50	1.60	1.00	1.70	1.10
11	1.00	1.75	1.60	1.00	1.70	1.10
12	1.00	1.80	1.50	1.00	1.80	1.10
13	1.00	2.00	1.50	.90	1.80	1.10
14	1.00	2.00	1.50	1.00	1.70	1.00
15	1.00	1.90	1.50	1.00	1.60	1.00
16	1.50	1.80	1.50	1.00	1.60	1.00
17	1.60	1.80	1.50	1.10	1.50	1.00
18	1.55	1.80	1.10	1.30	1.50	1.00
19	1.65	1.80	1.10	1.30	1.40	1.00
20	1.50	1.80	1.10	1.30	1.40	1.00
21	1.50	1.60	1.00	1.30	1.30	1.00
22	1.50	1.70	1.00	1.30	1.30	1.70
23	1.70	2.00	1.00	1.20	1.20	1.70
24	1.75	1.50	1.00	1.20	1.20	1.60
25	1.70	1.55	1.00	1.10	1.10	1.60
26	1.70	1.80	1.20	1.00	1.10	1.60
27	1.70	1.80	1.20	1.00	1.10	1.50
28	1.50	1.70	1.10	1.00	1.10	1.50
29	1.50	1.70	1.10	1.00	1.10	1.50
30	1.50	1.60	1.10	1.10	1.10	1.50
31	.....	1.65	.....	1.10	1.15	.....

Closed for the winter November 4.

GILA RIVER AT SAN CARLOS, ARIZONA.

river rises in southwestern New Mexico and has a general
esterly direction until it crosses the territorial line into Ari-
; about 32° 40′ north latitude. Its principal sources of supply
m the Black Range on the east, and from a number of ranges
west, including Little Range, Mogollon Range, and Diablo
The average elevation of these mountain peaks is from 9,000
00 feet. The general character of the country is a high and
plateau, with the river flowing through it in a deep canyon, and
actically no agricultural lands within its area. The river emerges
s upper canyon about 10 miles before it reaches the Arizona
id thence flows through a valley of considerable width, known
ican Valley, until just before it receives the waters of San
sco River. Duncan Valley, in which a number of ditches
water for irrigation purposes, will be described at length in
enty-first Annual Report. San Francisco River, the principal
ry of the upper Gila, has it source in the northeast corner of
n County, Arizona, but 15 miles below it passes into New
. Its general course is thence southerly, returning into Ari-
t about 33° north latitude. The area drained is high and moun-
s, the principal ranges being the San Francisco, the Tularosa,
e western slope of the Mogollon, with elevations ranging from
o 10,000 feet. The course of the river through this portion is
terized by a succession of canyons alternating with valley-like
gs, with the considerable fall of from 35 to 40 feet per mile.
River is in canyon for about 20 miles below the mouth of the San
sco, or to within 10 miles of Solomonsville. At this point the
parate, forming a large valley which has been extensively settled
now one of the finest irrigated portions of the Territory. The
of a series of seepage measurements made from 10 miles above
onsville down to Fort Thomas, with a description of the irriga-
terprises in this section, will be published in the Twenty-first
l Report. This valley extends from a point 10 miles above
onsville to 6 miles below the mouth of San Carlos River on the
Mountain Indian Reservation. At this latter place the moun-
suddenly close in again, and the river enters another canyon.
miles below the Indian agency at San Carlos the canyon boxes
idth of 100 feet, and at this point is located the San Carlos dam
which was studied in detail by the United States Geological
y during 1899, in connection with the investigation of the water
of Gila River. The results of this investigation are published
ter-Supply and Irrigation Paper No. 33, entitled Storage of
on Gila River, Arizona, by J. B. Lippincott. In connection
his investigation Cyrus C. Babb, on July 11, 1899, established a

station on Gila River one-half mile south of the Indian agency at San Carlos and below the mouth of San Carlos Creek. An inclined rod securely fastened to posts driven into the bank was erected here. The bench mark is a 20-penny nail in the base of a mesquite tree 5 inches in diameter, 85 feet west of the gage rod, at an elevation of 12.67 feet above gage datum. Discharge measurements are made from a cable and car a short distance above the gage rod. The channel is straight for some distance above and below the station, and the water is comparatively swift. The right bank is high, but the left is low and liable to overflow. The bed of the stream is sandy and shifting. The following measurements of discharge were made by Cyrus C. Babb and Stephen Janus during 1899:

Discharge measurements of Gila River at San Carlos, Arizona.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
August 4	3.63	1,638	September 14	2.10	312
September 6	2.30	170	September 19	1.90	127
September 7	3.20	849	September 29	1.50	77
September 8	5.45	8,453	October 6	2.30	215
September 9	3.60	2,130	October 14	1.80	108

Daily gage height, in feet, of Gila River at San Carlos, Arizona, for 1899.

Day.	July.	Aug.	Sept.	Oct.	Day.	July.	Aug.	Sept.	Oct.	Day.	July.	Aug.	Sept.	Oct.
1	.....	3.10	1.60	1.50	12	3.10	2.40	2.38	1.90	23	3.50	1.70	1.70	.....
2	.....	3.90	1.60	1.50	13	2.70	2.40	2.30	1.85	24	3.40	1.70	1.70	.....
3	.....	3.20	1.60	1.50	14	2.50	2.20	2.13	1.80	25	3.20	1.70	1.70	.....
4	.....	3.10	1.60	1.60	15	2.20	2.20	2.00	.....	26	3.10	1.70	1.70	.....
5	.....	2.80	1.55	1.60	16	2.30	2.00	2.00	.....	27	3.13	1.60	1.60	.....
6	.....	2.80	2.05	2.40	17	2.10	2.00	2.00	.....	28	3.07	1.60	1.60	.....
7	.....	2.90	2.60	2.30	18	2.30	1.80	2.00	.....	29	3.20	1.85	1.50	.....
8	.....	2.70	5.25	2.30	19	6.50	1.80	1.90	.....	30	2.90	1.60	1.50	.....
9	.....	3.00	3.10	2.00	20	4.90	1.80	1.85	.....	31	2.80	1.60	.....	.....
10	.....	2.80	2.80	1.90	21	3.60	1.80	1.80	.....					
11	4.00	2.50	2.60	1.90	22	3.50	1.80	1.70	.....					

Station discontinued October 14.

The following measurements were made by Cyrus C. Babb during a reconnaissance trip through the upper basin of Gila River in the spring of 1899. The measurements from March 11 to 17, inclusive, are of San Pedro River and of the ditches diverting water from it. The measurements on March 29, 30, and 31 were made on the ditches diverting water from Gila River above Duncan, Arizona. The measurements from April 15 to 17, inclusive, were made principally on ditches diverting water from Gila River in the Solomonsville Valley, and were made to determine the amount of seepage water returning to the stream. A discussion of these latter measurements will be made in the Twenty-first Annual Report, Part IV.

Miscellaneous discharge measurements in Gila River Basin, Arizona.

1899.

	Stream.	Locality.	Discharge.
			Second-feet.
1	Gila River	Above mouth of San Pedro	62.0
1	San Pedro River	Dudleyville	9.6
1	Burns and Lopez ditch.	Dudleyville	4.6
2	Scott and Cunningham ditch.	Dudleyville	6.6
2	San Pedro River	Below Scott and Cunningham ditch.	1.0
2	Swingle ditch	At head on San Pedro River.	3.7
2	Finch and Draper ditch.	At head on San Pedro River.	2.8
3	Dodson ditch	At head on San Pedro River.	7.6
3	San Pedro River	Below Dodson ditch	0.0
3	Cook ditch	At head on San Pedro River.	6.4
3	Busand ditch	At head on San Pedro River.	3.4
3	San Pedro River	1 mile below Mammoth	0.0
4	Brown ditch	At head on San Pedro River.	9.1
4	Clark ditch	At head on San Pedro River.	2.3
4	San Pedro River	Pinal and Pima counties line.	1.5
5	San Pedro River	Narrows	5.1
5	Los Angeles ditch	At head on San Pedro River.	4.2
6	San Pedro River	Line between townships 14 and 15 south.	10.0
7	St. David canal	2 miles above St. David	7.3
7	San Pedro River	Benson, Arizona, ½ mile below railroad.	6.5
7	Etts ditch	1 mile below railroad at Benson.	1.2
7	San Pedro River	5 miles south of Benson	5.7
2	Union ditch	Solomonsville	76.0
2	Gila River	Below head of Union ditch, Solomonsville.	10.0
9	Gila River	Below Telles ditch	156.0
0	Telles ditch	Above Duncan	4.0
0	Rucker ditch	Above Duncan	1.6
0	Hughes ditch	Above Duncan	2.8
0	Martin ditch	Above Duncan	3.0
0	Wilson ditch	Above Duncan	4.7
0	Casper and Windham ditch.	Above Duncan	6.8
0	Johnson ditch	Above Duncan	0.7
0	Schriver ditch	Above Duncan	6.2
0	Franklin ditch	Above Duncan	13.9
0	Valley canal	Above Duncan	22.9
0	Owens canal	Above Duncan	1.8
0	Day's ditch	Above Duncan	6.0
1	Ward and Courtney ditch.	Above Duncan	7.8
1	Black and McCloskey ditch.	Above Duncan	3.8
1	Gila River	Duncan	104.0
	San Francisco River	7 miles above Clifton	94.0
	Blue River	At mouth	43.0
	San Francisco River	Above mouth of Blue River.	54.0
	San Francisco River	Flume power house, below Clifton.	92.0
	Gila Piver	5 miles above San Francisco River.	95.0
	Brown ditch	Near head	0.6

Miscellaneous discharge measurements in Gila River Basin, Arizona—Continued.

1899—Continued.

Date	Stream.	Locality.	Discharge.
			Second-feet.
April 15	Sanchez ditch	Near head	7.6
April 15	Gila River	Narrows below Sanchez ditch	237.0
April 15	Mejia ditch	Below waste	4.3
April 15	Old San Jose ditch	Near head	11.6
April 15	San Jose ditch	Near head	45.0
April 15	Gila River	Below San Jose ditch	189.0
April 15	Waste	North side	2.0
April 15	Michelena ditch	Below waste gate	9.4
April 15	Montezuma ditch	Below waste gate	101.0
April 15	Gonzales ditch	Below waste gate	4.0
April 15	Gila River	Below Gonzales ditch	63.0
April 15	Waste	Montezuma ditch	27.0
April 15	Waste	Above Union ditch	10.0
April 15	Union ditch	At head	93.0
April 15	Gila River	Below Union ditch	10.4
April 16	Lee ditch	At head	3.3
April 16	Sunflower ditch	At head	4.9
April 16	Graham ditch	At head	18.6
April 16	Central ditch	At head	19.5
April 16	Gila River	Below Central ditch	6.8
April 16	Oregon ditch	At head	11.1
April 16	Smithville ditch	At head	13.2
April 16	Gila River	Below Smithville ditch	1.5
April 16	Brice ditch	At head	7.4
April 16	Dodge ditch	At head	6.7
April 17	Mathewsville ditch	At head	33.0
April 17	Gila River	Below Mathewsville ditch	2.8
April 17	Curtis ditch	At head	14.3
April 17	Gila River	Below Curtis ditch	0.0
April 17	Kempton ditch	At head	9.3
April 17	Vogel ditch	At head	0.0
April 17	Gila River	Below Vogel ditch	7.0
April 17	Reid ditch	At head	3.8
April 17	Gila River	Below Reid ditch	10.8
April 17	Fort Thomas ditch	At head	3.7
April 17	Upper Thompson ditch	At head	0.0
April 17	Lower Thompson ditch	At head	5.3
April 17	Military ditch	Flume at Fort Thomas	5.9
April 17	Saline ditch	At head	0.7
April 17	Mexican ditch	At head	0.8
April 17	Gila River	Opposite Fort Thomas	20.0
April 17	Gila River	3 miles below Fort Thomas	32.8
April 25	Indian ditch	San Carlos	12.2
April 28	Gila River	San Carlos Canyon	27.0
May 15	Gila River	Duncan	10.0
May 24	Gila River	San Carlos Canyon	7.0

GILA RIVER AT THE BUTTES, ARIZONA.

Gila River is in canyon from a short distance below the mouth of San Carlos River to about the mouth of San Pedro River, a distance of 31 miles. The country then broadens into a valley of considerable size, extending for a distance of about 20 miles, to below the mouth of Mineral Creek. This opening, known as Riverside Valley, was examined in detail in connection with the investigation of the water

ɔply of Gila River, and the lower portion was mapped by G. H. ıtthes as a reservoir site. From the mouth of Mineral Creek the er is in canyon again until what is known as the Buttes are reached—listance of about 15 miles, when the river appears on the Great ıins region of southwestern Arizona. Its general course is thence sterly until it enters the Colorado River at Yuma. The present tion at the Buttes was established February 20, 1896, in connection th the first investigation for a water supply for the Gila River lian Reservation. It is located about 16 miles above Florence, izona. The gage rod is bolted to a solid rock on the right bank ıere the river emerges from the lower end of the gorge. The nch mark is a rock point chiseled on a ledge 69.4 feet southeast the south cable support and 4.4 feet above the ground, and is at elevation of 1,608.45 feet above sea level. The elevation of the ro of the rod is 1,583.00 feet. Measurements at this point were ıde in connection with the investigation of the water supply of the la River by the United States Geological Survey, authorized by ɔcial act of Congress. The results of the work are published in ater-Supply and Irrigation Paper No. 33, entitled Storage of Water Gila River, Arizona, by J. B. Lippincott. The channel of the 'er at the Buttes is composed of quicksand and likely to change ily with any considerable amount of water in the river. In order to tain an accurate estimate of the daily discharge, it is necessary to make ıtinuous measurements, which was done during the investigation. ıe results of the measurements at this point will be found as follows: 96, Eighteenth Annual Report, Part IV, page 290; 1897, Nineteenth ınual Report, Part IV, page 416; 1898, Twentieth Annual Report, rt IV, page 405; 1899, Water-Supply and Irrigation Paper No. 33, ge 26. The following measurements of discharge were made during 99 by various members of the United States Geological Survey con-ɔted with the water-supply investigation:

Discharge measurements of Gila River at the Buttes, Arizona.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
January 14	3.20	634	March 4	2.50	139
January 25	2.75	245	March 6	2.50	123
February 3	2.90	616	March 8	2.50	142
February 3	2.86	547	March 10	2.50	146
February 4	2.90	514	March 13	2.40	122
February 6	2.80	327	March 15	2.40	93
February 7	2.68	222	March 17	2.55	120
February 9	2.70	265	March 21	2.60	142
February 11	2.80	333	March 23	2.60	135
February 13	2.80	270	March 25	2.60	130
February 14	2.75	290	March 28	2.50	118
February 15	2.75	272	March 30	2.50	95
February 18	2.65	193	April 1	2.50	86
February 24	2.60	209	April 2	2.50	90
February 27	2.60	184	April 5	2.50	100
March 2	2.50	165	April 7	2.45	97

Discharge measurements of Gila River at the Buttes, Arizona—Continued.

1899—Continued.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
April 10	2.45	73	August 17	2.55	316
April 12	2.40	66	August 19	2.40	207
April 14	2.40	64	August 23	2.25	112
April 17	2.40	59	August 25	2.10	89
April 19	2.35	51	August 29	2.00	71
April 19	2.35	53	August 31	2.00	77
April 21	2.30	50	September 2	2.00	50
April 21	2.30	56	September 4	1.90	42
April 24	2.30	48	September 5	1.90	24
April 24	2.30	48	September 6	1.90	31
April 26	2.30	36	September 7	2.70	367
April 28	2.25	38	September 7	3.90	2,234
May 1	2.25	38	September 8	8.30	10,187
May 3	2.20	29	September 9	4.95	2,923
May 5	2.20	32	September 11	3.50	1,382
May 6	2.15	26	September 12	3.00	734
May 9	2.15	26	September 14	2.07	399
May 11	2.10	24	September 15	2.60	357
May 13	2.10	24	September 16	2.50	288
May 15	2.05	19	September 17	2.40	249
May 17	2.00	12	September 18	2.30	205
May 18	2.00	13	September 19	2.30	202
May 20	2.00	14	September 20	2.20	147
May 23	2.00	8	September 21	2.20	130
May 25	2.00	11	September 22	2.20	126
May 27	1.95	13	September 23	2.10	99
May 29	1.95	7	September 24	2.10	108
May 31	1.90	4	September 25	1.05	93
June 2	2.20	30	September 26	2.00	82
June 5	2.00	12	September 26	2.00	62
June 7	1.90	16	September 27	2.00	77
June 9	1.90	4	September 27	.....	55
June 13	1.80	2	September 28	2.00	68
June 15	1.80	1	September 29	2.00	76
June 19	1.75	1	September 29	2.00	61
June 21	1.75	1	September 30	1.90	54
June 23	1.75	1	October 1	1.90	50
June 26	1.75	2	October 2	1.90	45
June 28	1.75	1	October 3	1.90	40
July 2	1.75	50	October 4	1.90	41
July 4	1.70	25	October 5	1.80	43
July 6	1.70	25	October 5	2.52	330
July 8	1.70	16	October 6	2.10	139
July 10	1.80	2	October 7	2.25	179
July 11	2.75	302	October 8	2.35	219
July 12	2.80	505	October 9	2.30	180
July 13	2.70	263	October 10	2.25	180
July 14	2.50	142	October 11	2.20	98
July 17	2.85	317	October 12	2.20	93
July 18	3.40	1,094	October 13	2.20	110
July 18	2.40	104	October 14	2.10	92
July 19	4.00	1,567	October 16	2.10	96
July 19	4.40	2,095	October 17	2.10	88
July 20	6.60	5,920	October 18	2.10	88
July 20	8.00	8,739	October 19	2.00	71
July 21	5.50	4,339	October 20	2.00	79
August 14	2.75	397	October 21	2.00	76

Measurements were also made of Arthur's ditch, which diverts water one-half mile below the gaging station, of the Florence canal, opposite White's ranch, and of Gila River near the latter place.

The following table shows the measurements made during 1899:

Discharge measurements of Gila River, Arthur's ditch, and Florence canal, Arizona.

1899.

Date.	Stream.	Locality.	Discharge.
			Second-feet.
March 17	Arthur's ditch	One-half mile below station	4.23
March 21	Arthur's ditch	One-half mile below station	4.20
March 21	Gila River	One-half mile below gate of Florence canal.	19.28
March 21	Florence canal	Opposite White's ranch	101.19
April 17	Arthur's ditch	One-half mile below Butte station.	2.15
April 17	Gila River	Below head gate, opposite White's house.	13.43
April 17	Florence canal	At White's ranch, opposite house.	42.61
May 6	Arthur's ditch	On Gila River	3.48
May 6	Gila River	Below Florence canal	8.51
May 6	Florence canal	At White's ranch	10.76
May 18	Gila River	At head of Arthur's ditch at the Buttes.	2.70
May 18	Gila River	Below Florence canal	2.27
May 18	Gila River	Opposite White's ranch	2.94

Daily gage height, in feet, of Gila River at the Buttes, Arizona, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	2.80	2.69	2.50	2.50	2.25	1.90	1.75	4.00	2.00	1.90
2	2.78	2.73	2.50	.....	2.20	2.20	1.70	4.70	2.00	1.90
3	2.89	2.88	2.50	2.45	2.20	2.10	1.70	5.50	.....	1.90
4	2.73	2.93	2.50	2.50	2.20	.....	1.70	4.50	1.90	1.90
5	2.70	2.91	.....	2.50	2.20	2.00	1.70	4.00	1.87	2.15
6	2.65	2.78	2.50	2.50	2.15	1.95	1.70	3.70	1.95	2.15
7	2.69	2.69	2.50	2.45	.....	1.90	1.70	3.30	3.30	2.25
8	2.63	2.71	2.50	2.45	2.15	1.90	1.70	4.50	3.30	2.37
9	2.68	2.72	2.50	.....	2.15	1.90	.....	3.70	4.85	2.30
10	2.60	2.70	2.50	2.45	2.10	1.85	1.80	3.30	4.30	2.22
11	2.73	2.73	2.40	2.45	2.10	1.80	2.75	3.30	3.35	2.20
12	2.70	2.80	.....	2.40	2.10	1.80	2.80	3.10	3.00	2.20
13	3.30	2.80	2.40	2.40	2.10	1.80	2.70	2.80	2.80	2.20
14	3.15	2.78	2.40	2.40	.....	1.80	2.50	2.80	2.65	2.10
15	3.00	2.75	2.40	2.40	2.05	1.80	2.40	2.70	2.60	2.10
16	3.00	2.70	2.50	.....	2.05	1.75	.....	2.60	2.50	2.10
17	2.95	2.67	2.55	2.40	2.00	1.75	2.70	2.50	2.40	2.10
18	2.93	2.68	2.55	2.40	2.00	.....	3.10	2.50	2.30	2.05
19	2.80	2.65	.....	2.35	2.00	1.75	4.20	2.40	2.30	2.00
20	2.73	2.63	2.60	2.30	2.00	1.75	7.30	2.40	2.20	2.05
21	2.70	.....	2.60	2.30	.....	1.75	5.50	.....	2.20	2.05
22	2.70	2.65	.....	2.30	2.00	1.75	4.50	2.30	2.20	.....
23	2.80	2.60	2.60	.....	2.00	1.75	.....	2.30	2.10	.....
24	2.80	2.60	2.50	2.30	2.00	1.75	4.00	2.20	2.10	.....
25	2.75	2.60	2.60	2.30	2.00	1.75	3.90	2.10	2.05	.....
26	.....	2.60	.....	2.30	2.00	1.75	4.00	2.10	2.00	.....
27	2.75	2.60	2.50	2.30	1.95	1.75	4.00	2.10	2.00	.....
28	2.70	2.50	2.50	2.25	.....	1.75	5.25	2.00	2.00	.....
29	2.75	.....	2.50	2.25	1.95	1.75	.....	2.00	1.97	.....
30	2.70	.....	2.50	.....	1.90	.....	.....	2.00	1.90	.....
31	2.68	.....	2.50	.....	1.90	.....	.....	2.00	.....	.....

Station discontinued October 11.

QUEEN CREEK AT WHITLOW'S RANCH, ARIZONA.

This creek is a tributary of the Gila, and has its source in the Pinal Mountains, 40 miles northeast of Florence, Arizona. A short distance below Whitlow's ranch its waters ordinarily are lost in the sands of the desert, and it is only during protracted floods that the discharge continues southwestward, entering Gila River below the Sacaton Range. This basin was under examination in connection with the investigation of the water supply of Gila River.[1]

The discharge of this creek is intermittent, depending upon sudden and violent floods, which are generally of short duration, usually extending over a period of only one day. In order to obtain an accurate estimate of its flow, it is necessary to have an observer constantly on the ground. The station at Whitlow's was established in February, 1896, and was discontinued in April, 1897. It was resumed November 16, 1898, when the original rod was extended, lowering the zero 3 feet. On the same day a sloping rod, referred to the same datum, was placed 431 feet upstream from the main gage. Measurements can be made from a cable and car. It was impracticable, during 1899, to use a meter at this point, so the observer, during the flood stages, observed both gages at short intervals and took soundings from which a cross section could be computed. The discharges were figured by Kutter's formula from these measurements of soundings, and from the slope as determined by the observations of heights on the two rods. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 293; 1897, Nineteenth Annual Report, Part IV, page 418. The following table shows the dates on which there was a discharge in the creek, together with the number of second-feet.

Discharge measurements of Queen Creek at Whitlow's ranch, Arizona.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
January 12	2.00	.....	June 26	2.30	10
January 12	3.00	.....	July 9	3.00	81
January 13	2.60	.....	July 10	3.10	148
January 13	2.40	.....	July 13	4.50	884
January 14	2.30	.....	July 13	2.40	3
January 14	2.20	.....	July 16	4.00	529
February 3	3.00	87	July 18	3.50	274
February 3	2.80	57	July 25	2.50	2
February 4	2.70	49	July 26	2.50	2
February 4	2.50	11	July 29	2.60	27
February 5	2.40	8	July 30	7.10	5,515
March, April, May	Creek dry	.....	August 1	4.50	492
			August 2	8.00	4,600
			August 2	6.00	1,562
June 2	2.70	62	September 7	7.50	.....
June 2	2.30	16	September 8	7.00	.....
June 25	5.00	1,171			

[1] *Storage of water on Gila River, Arizona, by J. B. Lippincott: Water-Supply and Irrigation Paper No. 33.*

SALT RIVER AT MCDOWELL, ARIZONA.

This river is the principal tributary of Gila River, and rises in aham County, Arizona, its headwater tributaries adjoining those San Francisco River. A large portion of its course is through the untainous district of the White Mountain Indian Reservation. igation is practiced to a small extent in what is known as Tonto lley, but shortly after Tonto Creek joins it the river enters a canyon ain and continues in it until a short distance above the mouth of rde River. At this point the river reappears from its canyon, and its urse is thence across the Plains district until it enters Gila River at northwest corner of Gila River Indian Reservation. From the uth of Verde River down to Gila River a number of large canals vert the water of Salt River and serve the extensively irrigated ds in the vicinity of Phœnix on the north side and Mesa on the uth side of the river. During ordinary seasons all of the water of lt River is diverted, and at the present time there is a shortage in summer months. The gaging station, established April 20, 1897, located one-half mile above the mouth of the Verde and 30 miles rtheast of Phœnix. The gage consists of a 2 by 6 inch scantling lted to rocks on the south side of the river about 300 feet above the ble. The bench mark is a nail in a palo verde tree about 75 feet st of the north cable anchorage and is 17.33 feet above gage zero. e bed of the river is sandy and shifting, and it is necessary to make arge number of measurements in order to obtain an accurate estiate of the discharge. The results of measurements may be found follows: 1897, Nineteenth Annual Report, Part IV, page 420; 1898, wentieth Annual Report, Part IV, page 406. The following disarge measurements were made by W. A. Farish during 1899:

Discharge measurements of Salt River at McDowell, Arizona.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
January 15	11.40	530	July 16	10.35	204
January 22	11.05	367	August 22	10.55	244
February 12	11.20	390	September 4	10.20	144
February 28	11.20	426	September 10	11.50	716
March 12	11.20	519	October 8	10.40	178
March 31	11.30	602	October 15	11.90	496
April 29	10.85	481	November 30	11.00	226
April 30	10.89	475	December 1	10.95	331
June 29	10.10	173			

A series of measurements of canals diverting water from Salt River the vicinity of Phœnix were made by Cyrus C. Babb from June 12 to , inclusive, in order to determine the amount of return water to the er through seepage. A similar series of measurements were made

in June, 1896. A discussion of these two sets of seepage measurements will be made in the Twenty-first Annual Report.

Miscellaneous discharge measurements in Salt River Valley, Arizona.

1899.

Date.	Stream.	Locality.	Discharge.
			Second-feet.
June 12	Salt River	Gaging station	197.0
June 12	Verde River	Gaging station	140.0
June 13	Arizona canal	Below waste gate	185.0
June 13	Arizona waste	At river	88.0
June 13	Salt River	Opposite Arizona waste gate.	18.7
June 13	Highland canal	Opposite Arizona waste gate.	31.7
June 13	Mesa Consolidated	Below waste gate	67.7
June 13	Small flume	Mesa waste gate	1.8
June 13	Mesa Consolidated waste.	Near gate	15.3
June 13	Salt River	Opposite Mesa Consolidated waste gate.	5.8
June 13	Tempe canal	Ford near head	70.6
June 13	Salt River	Opposite Tempe canal head.	0.0
June 13	Salt River	Railroad bridge	59.8
June 15	Salt River	South of Phoenix	0.0
June 15	St. Johns canal	At head	7.8
June 15	Salt River	Below head of St. Johns canal.	23.9
June 15	Buckeye canal	At head	102.3
June 15	Salt River	Below Buckeye canal	1.0

Daily gage height, in feet, of Salt River at McDowell, Arizona, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	10.80	10.95	11.20	11.30	10.90	10.25	10.10	13.50	10.30	10.30	10.95
2	10.85	11.00	11.15	11.25	10.95	10.35	10.10	17.00	10.35	10.30	10.80
3	10.70	11.10	11.10	11.20	10.80	10.40	10.10	14.30	10.30	10.30	10.80
4	10.70	11.40	11.10	11.15	10.75	10.45	10.05	13.00	10.40	10.40	10.80
5	10.70	11.30	11.15	11.15	10.80	10.45	10.10	12.90	10.40	10.40	10.90
6	10.65	11.25	11.20	11.10	10.75	10.40	10.10	12.70	70.40	10.40	10.90
7	10.70	11.20	11.25	11.20	10.75	10.35	10.05	12.20	10.35	10.40	10.90
8	10.70	11.15	11.25	11.30	10.70	10.35	10.05	11.90	10.30	10.45	10.90
9	10.70	11.10	11.20	11.30	10.65	10.35	10.05	11.10	11.45	10.40	10.90
10	10.70	11.05	11.20	11.30	10.60	10.40	10.10	11.95	12.60	10.40	10.90
11	10.65	11.30	11.20	11.35	10.55	10.30	10.25	11.30	11.65	10.40	10.90
12	11.05	11.20	11.25	11.30	10.50	10.25	10.60	11.40	11.50	10.55	10.90
13	11.90	11.30	11.30	11.35	10.50	10.20	10.50	11.20	11.30	12.70	10.90
14	11.65	11.35	11.25	11.35	10.45	10.20	10.80	11.00	11.00	11.90	11.00
15	11.70	11.30	11.20	11.35	10.50	10.20	10.50	11.00	10.80	11.85	11.00
16	11.30	11.20	11.15	11.35	10.55	10.20	10.40	10.90	10.70	12.30	11.00
17	11.20	11.15	11.10	11.30	10.55	10.20	10.90	11.05	10.60	11.80	11.00
18	11.15	11.15	11.05	11.35	10.55	10.15	10.90	10.95	10.55	11.50	11.00
19	11.15	11.10	11.05	11.35	10.50	10.15	10.80	10.80	10.50	11.30	11.00
20	11.25	11.10	11.10	11.30	10.55	10.10	10.70	10.60	10.45	11.00	11.00
21	11.10	11.10	11.10	11.25	10.55	10.20	11.00	10.60	10.45	11.00	11.00
22	11.10	11.10	11.10	11.25	10.55	10.15	10.75	10.55	10.45	11.00	11.00
23	11.05	11.10	11.10	11.20	10.55	10.20	11.50	10.40	10.40	11.00	11.00
24	11.05	11.15	11.10	11.15	10.60	10.30	11.40	10.40	10.35	11.00	11.00
25	11.00	11.15	11.10	11.15	10.60	10.20	12.50	10.45	10.35	11.00	11.00
26	11.00	11.20	11.10	11.15	10.55	11.10	11.60	10.40	10.35	11.00	11.00
27	10.90	11.20	11.20	11.10	10.50	10.50	11.70	10.40	10.35	10.95	11.00
28	10.90	11.20	11.35	11.10	10.45	10.15	11.60	10.35	10.35	10.95	11.00
29	10.90	.....	11.30	11.05	10.40	10.10	12.70	10.30	10.35	10.95	11.00
30	10.90	.....	11.40	10.90	10.35	10.10	12.80	10.30	10.30	10.90	11.00
31	10.90	.....	11.30	.....	10.30	.....	13.00	10.40	.....	10.90	.....

Station discontinued November 30.

VERDE RIVER AT MCDOWELL, ARIZONA.

This river rises in north-central Arizona and flows in a general outherly direction, entering Salt River 30 miles northeast of Phœnix. . number of large irrigation enterprises have recently been planned nd are now in course of construction, designed to divert water from he lower stretch of the river to irrigate lands north of Phœnix. The esults of measurements of this river combined with those of Salt River now the amount of water available for the irrigable lands of Phœnix 'alley. The dam of the Arizona Canal Company is located on Salt River immediately below the mouth of the Verde. The gaging station f this latter stream is located three-fourths of a mile above its mouth nd 30 miles northeast of Phœnix. It was established April 20, 1897. he station is equipped with a cable, car, and tagged wire. The gage onsists of a 2 by 4 inch inclined rod fastened to posts driven into the ast bank of the river about 400 feet below the gaging cable. The ench mark is on a cat's claw tree about 100 feet southeast from the ld gage, on a cottonwood tree, which latter is 60 feet below the cable. he elevation of the bench mark is 27.02 feet above gage datum. The hannel of the river is similar to that of Salt River—sandy and liable to hange during a slight rise, and a large number of measurements are ecessary in order to accurately determine the discharge. The results f measurements may be found as follows: 1897, Nineteenth Annual Report, Part IV, page 420; 1898, Twentieth Annual Report, Part IV, age 407. The following measurements of discharge were made by V. A. Farish during 1899.

Discharge measurements of Verde River at McDowell, Arizona.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
January 15	7.65	454	July 16	7.50	254
January 22	7.50	356	August 5	8.90	1,213
February 12	7.70	374	August 22	7.35	139
February 28	7.55	324	September 4	7.40	146
March 12	7.55	262	September 10	8.20	481
March 30	7.50	231	October 8	7.50	206
April 29	7.35	191	October 15	9.20	1,670
April 30	7.40	209	November 30	7.80	303
June 29	7.15	127	December 1	7.75	265

Daily gage height, in feet, of Verde River at McDowell, Arizona, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	7.45	7.55	7.55	7.50	7.40	7.15	7.20	8.00	7.35	7.35	7.70
2	7.45	7.55	7.50	7.50	7.40	7.20	7.15	8.30	7.40	7.35	7.70
3	7.45	7.60	7.50	7.50	7.35	7.25	7.15	9.00	7.50	7.35	7.70
4	7.50	7.40	7.55	7.50	7.30	7.20	7.10	9.00	7.40	7.60	7.65
5	7.40	7.60	7.55	7.50	7.30	7.35	7.10	9.50	7.40	7.70	7.70
6	7.40	7.60	7.55	7.50	7.30	7.35	7.10	8.90	7.35	7.50	7.70
7	7.40	7.60	7.55	7.45	7.30	7.35	7.10	8.60	7.40	7.45	7.70
8	7.45	7.55	7.55	7.40	7.30	7.35	7.10	8.30	9.60	7.45	7.70
9	7.40	7.55	7.55	7.45	7.35	7.35	7.10	8.10	9.70	7.45	7.70
10	7.40	7.65	7.55	7.40	7.35	7.30	7.25	8.00	8.30	7.50	7.70
11	7.45	7.70	7.55	7.40	7.25	7.20	7.40	7.80	8.00	7.55	7.70
12	7.40	7.70	7.55	7.40	7.20	7.25	7.70	7.60	7.85	10.50	.....
13	7.80	7.65	7.55	7.40	7.20	7.20	7.60	7.65	7.70	8.60	.....
14	7.75	7.65	7.55	7.40	7.20	7.20	7.80	7.55	7.65	8.50	.....
15	7.70	7.65	7.55	7.40	7.20	7.20	7.60	7.45	7.50	9.30	.....
16	7.45	7.60	7.55	7.35	7.25	7.20	7.70	7.40	7.50	9.25	.....
17	7.40	7.55	7.55	7.30	7.25	4.20	7.50	7.55	7.50	8.60	.....
18	7.45	7.65	7.55	7.35	7.25	7.15	7.40	7.50	7.50	8.20	.....
19	7.45	7.65	7.50	7.35	7.20	7.15	7.60	7.40	7.50	8.20	.....
20	7.60	7.55	7.50	7.35	7.15	7.10	8.40	7.35	7.45	8.00	.....
21	7.60	7.60	7.50	7.35	7.10	7.10	7.60	7.35	7.45	8.00	.....
22	7.50	7.60	7.55	7.35	7.10	7.10	7.45	7.35	7.45	7.90	.....
23	7.45	7.60	7.55	7.35	7.10	7.20	8.50	7.30	7.40	7.85	.....
24	7.50	7.60	7.50	7.35	7.10	7.30	8.25	7.30	7.45	7.80	.....
25	7.55	7.60	7.50	7.35	7.15	7.20	9.05	7.25	7.45	7.80	.....
26	7.50	7.70	7.50	7.35	7.20	7.20	8.60	7.25	7.40	7.80	.....
27	7.40	7.60	7.50	7.40	7.20	7.45	7.70	7.25	7.40	7.80	.....
28	7.55	7.55	7.50	7.35	7.20	7.25	7.75	7.20	7.40	7.80	.....
29	7.45	.....	7.55	7.35	7.20	7.15	8.20	7.20	7.35	7.75	.....
30	7.55	.....	7.55	7.40	7.20	7.15	8.00	7.20	7.40	7.75	.....
31	7.55	.....	7.55	.....	7.20	.....	7.80	7.35	.....	7.70	.....

Station discontinued November 11.

COLORADO RIVER AT YUMA, ARIZONA.

This river drains one of the largest areas in the West. It is formed by the junction of Green and Grand rivers in Utah, and flows in a general southerly direction until it enters the Grand Canyon in northern Arizona, when its general direction is westerly for some distance, and then southerly. It forms the boundary line between Nevada and Arizona, and lower down between California and Arizona. It enters the Gulf of California 70 miles below Yuma. The station is located at the Southern Pacific railroad bridge across the Colorado River at Yuma, Arizona. The gage is fastened to a tall pile about 100 feet east of the north end of the bridge. Low-water readings are taken from a gage placed on the west end of the southern pier. The record here has been kept by the Southern Pacific Railroad Company since April, 1878, and is furnished to this office. No measurements of discharge were made here in 1899.

Daily gage height, in feet, of Colorado River at Yuma, Arizona, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	17.75	18.58	19.00	19.00	20.50	23.42	25.67	20.83	18.83	18.00	18.25	18.58
2....	17.92	18.50	19.08	18.83	20.67	23.33	25.58	20.83	18.75	17.92	18.25	18.58
3....	18.00	18.58	19.25	19.00	21.25	23.67	25.58	20.75	18.75	17.83	18.25	18.67
4....	17.92	18.58	19.50	19.00	21.50	23.67	25.50	20.67	18.67	17.75	18.25	18.58
5....	17.83	18.58	19.75	19.00	21.75	23.67	25.33	20.92	18.58	17.75	18.33	18.50
6....	17.75	18.67	19.75	19.00	22.00	23.83	25.00	21.17	18.50	17.75	18.33	18.58
7....	17.75	18.67	19.75	19.00	22.08	23.83	24.75	21.33	18.42	17.75	18.25	18.58
8....	17.92	18.67	19.67	19.00	22.17	24.00	24.67	21.50	18.42	17.67	18.33	18.58
9....	18.08	18.67	19.58	19.83	21.83	24.33	24.50	21.17	18.42	17.50	18.33	18.67
10....	18.08	18.75	19.58	20.17	21.42	24.17	24.33	21.50	18.42	17.50	18.33	18.58
11....	18.00	18.75	19.42	19.83	21.17	24.00	24.33	21.67	18.42	17.50	18.25	18.33
12....	17.83	18.75	19.08	19.75	21.00	23.67	24.08	21.75	18.42	17.50	18.25	18.33
13....	17.75	18.75	19.00	19.58	20.75	23.67	24.00	21.67	18.25	17.33	18.25	18.25
14....	17.67	18.83	19.00	19.50	20.50	23.83	23.83	21.83	18.33	17.25	18.17	18.17
15....	17.75	18.83	19.00	19.50	20.50	24.00	23.75	20.83	18.33	17.17	18.17	18.17
16....	18.00	18.92	19.00	19.50	20.67	24.08	23.33	20.33	18.33	17.00	18.17	18.25
17....	18.42	18.92	19.17	19.58	21.00	24.33	23.17	20.00	18.33	17.00	18.17	18.25
18....	18.58	18.75	19.17	19.50	21.50	24.33	23.00	19.92	18.17	17.00	18.17	18.08
19....	18.67	18.67	19.25	19.50	22.33	24.33	22.83	19.67	18.17	17.08	18.17	18.00
20....	18.67	18.58	19.17	19.50	23.42	24.58	22.58	19.50	18.08	17.08	18.25	17.83
21....	18.67	18.67	19.08	19.42	23.83	24.83	22.42	19.42	18.00	17.08	18.50	17.75
22....	18.67	18.75	19.17	19.42	24.00	25.00	22.17	19.33	17.92	17.17	18.50	17.67
23....	18.75	18.83	19.17	19.50	24.17	25.00	22.00	19.33	17.83	18.67	18.42	17.67
24....	18.67	18.75	19.17	19.58	24.33	25.17	22.00	19.42	17.83	19.17	18.42	17.67
25....	18.67	18.83	19.25	19.67	24.50	25.25	21.67	19.50	17.67	18.92	18.42	17.58
26....	18.67	18.75	19.33	20.33	24.50	25.33	21.83	19.00	17.50	18.67	18.50	17.67
27....	18.67	18.92	19.25	20.92	24.50	25.33	21.75	19.00	18.67	18.50	18.50	17.58
28....	18.58	18.92	19.17	20.92	24.17	25.50	21.50	19.08	18.17	18.25	18.50	17.50
29....	18.42	.....	19.08	20.83	23.83	25.75	21.33	19.00	18.08	18.17	18.50	17.50
30....	18.50	.....	19.00	20.58	23.50	25.67	21.17	18.92	18.00	18.17	18.58	17.33
31....	18.50	.....	19.00	.....	23.33	.....	21.00	18.83	.....	18.25	.....	17.42

NORTH FORK OF HUMBOLDT RIVER AT PEKO, NEVADA.

This tributary of Humboldt River rises in northern Nevada, its eadwaters adjoining those of the Owyhee River on the north. Its eneral course is southerly through a rolling country until it joins ie main Humboldt River. The gaging station, established March i, 1898, by L. H. Taylor, is located at the Southern Pacific railroad ridge about 2 miles west of Peko and a short distance above the mouth f the river. The gage is a vertical timber spiked to the pile support f the railroad bridge. The bench mark is on the stone abutment on ie east end of the bridge, on the left bank, and is 12 feet above gage itum. The channel above and below the station is curved, and the irrent is moderately swift. The bed of the stream is of sand and ravel, shifting somewhat during high stages. The results of measrements for 1898 are shown in the Twentieth Annual Report, Part V, page 436. The following measurements of discharge were made y L. H. Taylor during 1899:

April 28, gage height, 5 feet; discharge, 732 second-feet.
May 15, gage height, 4.50 feet; discharge, 504 second-feet.
June 26, gage height, 5.70 feet; discharge, 1,053 second-feet.
July 22, gage height, 4 feet; discharge, 331 second-feet.
August 29, gage height, 3.10 feet; discharge, 104 second-feet.
September 30, gage height, 1.75 feet; discharge, 6 second-feet.

Daily gage height, in feet, of North Fork of Humboldt River at Peko, Nevada, fo

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	2.20	2.40	2.60	4.00	4.50	4.20	4.60	4.20	2.70	1.70	2.30
2	2.20	2.60	2.60	4.00	4.40	4.00	4.50	4.10	2.70	1.70	2.30
3	2.40	2.60	2.70	4.00	4.30	4.00	4.50	4.00	2.70	1.70	2.30
4	2.40	2.60	2.70	4.20	4.20	4.00	4.60	4.00	2.70	1.70	2.30
5	2.60	2.50	2.80	4.20	4.10	4.10	4.60	4.00	2.80	1.80	2.30
6	2.70	2.50	2.90	4.30	4.00	4.20	4.50	3.90	2.80	1.80	2.30
7	2.70	2.60	2.90	4.30	4.00	4.30	4.40	3.70	2.70	1.80	2.30
8	2.20	2.60	3.00	4.30	3.40	4.40	4.30	3.60	2.60	1.70	2.40
9	2.20	2.60	3.40	4.80	3.00	4.40	4.20	3.40	2.60	1.70	2.40
10	2.30	2.70	3.50	4.90	3.00	4.40	4.20	3.20	2.70	1.70	2.40
11	2.30	2.70	3.60	5.00	3.40	4.20	4.30	3.10	2.80	1.80	2.40
12	2.40	2.50	3.20	5.00	3.50	4.30	4.20	3.10	2.80	1.80	2.40
13	2.40	2.50	3.20	5.40	3.40	4.40	4.10	3.00	2.80	1.80	2.40
14	2.40	2.60	3.30	5.60	4.40	4.50	4.20	3.00	2.70	1.90	2.30
15	2.70	2.60	3.30	6.30	4.50	4.70	4.10	2.90	2.60	2.00	2.30
16	2.70	2.60	3.40	6.80	4.60	4.90	4.20	2.80	2.60	2.00	2.20
17	2.80	2.60	3.40	6.80	4.70	5.00	4.20	2.80	2.60	2.00	2.10
18	2.80	2.60	3.50	6.70	4.70	5.60	4.00	2.70	2.60	2.00	2.10
19	2.90	3.30	3.60	6.70	4.80	5.80	4.00	2.70	2.60	2.10	2.10
20	3.00	3.30	3.60	6.60	4.80	5.90	4.10	3.00	2.50	2.10	2.10
21	3.00	3.30	3.70	6.50	4.00	6.00	4.00	3.00	2.50	2.10	2.20
22	2.40	3.40	3.70	6.00	4.10	6.00	4.00	2.90	2.50	2.10	2.20
23	2.40	3.40	3.80	5.20	4.20	6.10	4.60	2.90	2.40	2.10	2.20
24	2.50	3.50	3.90	5.20	4.30	6.00	4.60	2.80	2.30	2.10	2.20
25	2.50	3.50	4.00	5.30	4.30	5.90	4.50	2.80	2.20	2.10	2.30
26	2.60	2.50	3.60	5.30	4.40	5.60	4.50	2.80	2.00	2.20	2.20
27	2.60	2.50	3.70	5.20	4.40	5.30	4.40	2.80	1.90	2.20	2.20
28	2.60	2.50	3.70	5.00	4.00	5.20	4.20	2.90	1.80	2.20	2.20
29	2.20	.....	3.70	4.70	4.00	4.90	4.20	2.90	1.80	2.20	2.10
30	2.20	.....	3.80	4.60	4.10	4.70	4.30	2.80	1.80	2.20	2.10
31	2.40	.....	3.90	.....	4.20	.....	4.30	2.80	.....	2.30	.....

HUMBOLDT RIVER AT ELKO, NEVADA.

This river rises in the extreme northeastern part of Neva flows in a general westerly and southerly direction, finally e Humboldt Lake, whence its waters find their way into Humbo Carson sinks. The general direction of the mountain ranges basin is north and south, crossed at nearly right angles by tl Humboldt River. The tributaries flow in the general directio mountain ranges and drain either northward or southward. T may be divided into three divisions—the eastern, or headwat sion, separated from the middle or Battle Mountain Valley by Canyon; the central and western divisions, separated by Hot Range on the north and by Battle Mountain and Sonoma range south. There is a large body of agricultural land in the Humboldt River which at the present time is not wholly re During low stages the river is wholly diverted. For the development of the country recourse must be had to the cons of reservoirs for storage purposes. The station at Elko, est June 17, 1895, by L. H. Taylor, is located at the highway mile southwest of the town. The gage is inclined, fastened bolts driven into the solid rock, and is placed on the left ban diately below the bridge. The bench mark is on the southwes of the cofferdam surrounding the stone pier of the bridge north of the gage, and is at an elevation of 7.50 feet abo datum. The right bank is quite low, the left is high and rock

d of the stream is of gravel and sand, with a slight tendency to ange its channel during flood stages. The results of measurements ay be found as follows: 1896, Eighteenth Annual Report, Part IV, ge 300; 1897, Nineteenth Annual Report, Part IV, page 425; 1898, ventieth Annual Report, Part IV, page 437. The following measureents of discharge were made by L. H. Taylor during 1899:

Discharge measurements of Humboldt River at Elko, Nevada.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
April 27	6.40	1,421	July 2	7.10	1,817
May 10	5.40	984	July 22	4.50	630
June 10	5.90	1,245	August 28	2.80	144
June 26	7.80	2,260	September 29	2.10	31

Daily gage height, in feet, of Humboldt River at Elko, Nevada, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.90	2.30	2.75	4.35	6.40	5.70	7.20	3.70	2.80	2.15	3.50	2.80
2	1.90	2.30	2.80	4.25	6.10	5.80	7.15	3.60	2.80	2.15	3.50	2.75
3	1.90	2.35	2.85	4.20	5.80	5.80	7.00	3.40	2.80	2.15	3.55	2.60
4	1.90	2.35	2.85	4.20	5.60	5.80	6.90	3.30	2.80	2.15	3.55	2.59
5	1.90	2.35	2.90	4.20	5.60	5.80	6.90	3.20	2.80	2.15	3.55	2.58
6	1.90	2.35	3.00	4.20	5.60	5.80	6.75	3.20	2.80	2.15	3.55	2.57
7	1.90	2.35	3.00	4.20	5.80	5.90	6.60	3.10	2.80	2.15	3.55	2.58
8	1.90	2.35	3.05	4.20	5.70	5.90	6.40	3.10	2.80	2.20	3.55	2.59
9	1.90	2.30	3.05	4.35	5.55	5.90	6.20	3.10	2.80	2.20	3.55	2.60
10	1.90	2.30	3.05	4.40	5.40	5.95	6.05	3.10	2.70	2.20	3.60	2.60
11	1.95	2.30	3.05	4.90	5.20	6.00	5.80	2.90	2.70	2.20	3.60	2.60
12	1.95	2.30	3.05	5.15	5.20	6.20	5.65	2.90	2.70	2.40	3.60	2.60
13	1.95	2.35	3.05	5.50	5.20	6.30	5.50	2.70	2.70	2.80	3.60	2.65
14	1.95	2.35	3.10	6.20	5.35	6.40	5.30	2.60	2.70	2.90	3.62	2.65
15	1.90	2.35	3.15	6.90	5.65	6.60	5.25	2.50	2.70	3.15	3.62	2.60
16	1.95	2.35	3.15	7.30	5.90	7.00	5.20	2.50	2.70	3.15	3.65	2.60
17	2.00	2.40	3.10	7.20	6.30	7.25	5.10	2.60	2.60	3.20	3.65	2.58
18	2.00	2.40	3.05	7.15	6.50	7.20	4.90	2.60	2.60	3.20	3.65	2.55
19	2.00	2.50	3.15	7.15	6.75	7.30	4.75	2.70	2.60	3.25	3.65	2.54
20	2.05	2.55	3.20	7.15	6.80	7.30	4.50	2.90	2.60	3.30	3.65	2.54
21	2.05	2.60	3.20	7.10	6.65	7.50	4.50	2.80	2.60	3.30	3.66	2.53
22	2.15	2.60	3.30	7.10	6.40	7.75	4.50	2.80	2.60	3.30	3.67	2.52
23	2.15	2.70	3.40	6.80	6.10	8.00	4.50	2.80	2.50	3.35	3.67	2.50
24	2.20	2.70	3.70	6.60	5.85	8.00	4.50	2.80	2.50	3.35	3.67	2.50
25	2.25	2.70	3.75	6.50	5.40	8.00	4.35	2.80	2.40	3.40	3.67	2.48
26	2.30	2.75	4.60	6.50	5.10	7.80	4.30	2.80	2.30	3.40	3.60	2.45
27	2.35	2.75	4.55	6.40	5.10	7.70	4.20	2.80	2.20	3.45	3.40	2.43
28	2.35	2.75	4.45	6.40	5.10	7.60	4.15	2.80	2.10	3.45	3.15	2.40
29	2.30	.....	4.40	6.40	5.45	7.50	4.00	2.80	2.10	3.45	3.00	2.39
30	2.30	.....	4.35	6.40	5.50	7.35	3.90	2.80	2.10	3.45	2.90	2.36
31	2.30	.....	4.35	.....	5.60	.....	3.80	2.80	.....	3.45	.....	2.35

SOUTH FORK OF HUMBOLDT RIVER AT MASON'S RANCH, NEVADA.

This tributary rises in Eureka and White Pine counties, and takes nearly due north course, entering the main Humboldt River 10 miles below Elko. The little irrigation practiced in the basin is almost xclusively for forage plants. The measurements of discharge show he amount of water available for storage. There is a good site for a eservoir a short distance above the station. The station, established August 29, 1896, by L. H. Taylor, is located 10 miles southwest of

the town of Elko and about 6 miles above the junction of the South Fork with the main stream. The gage is inclined and spiked to posts driven firmly into the right bank. The bench mark is the top of a 2 by 4 inch post, 2½ feet long, driven flush with the ground 10 feet north of the gage, and is at an elevation of 7.50 feet above gage datum. The measurements are made from a cable and suspended car, at a point 1 mile above the gage, the latter being placed near the farm of the observer, for his convenience. At the point of measurement the banks are high, and the channel is straight for some distance above and below the station. The bed of the stream is of rock and gravel and quite stable. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 311; 1897, Nineteenth Annual Report, Part IV, page 430; 1898, Twentieth Annual Report, Part IV, page 440. The following discharge measurements were made by L. H. Taylor during 1899:

April 27, gage height, 2.50 feet; discharge, 404 second-feet.
May 10, gage height, 1.80 feet; discharge, 227 second-feet.
June 10, gage height, 3.30 feet; discharge, 658 second-feet.
June 25, gage height, 4.80 feet; discharge, 1,122 second-feet.
July 2, gage height, 4.15 feet; discharge, 910 second-feet.
August 28, gage height, 0.75 foot; discharge, 42 second-feet.
September 29, gage height, 0.55 foot; discharge, 20 second-feet.

Daily gage height, in feet, of South Fork of Humboldt River at Mason's ranch, Nevada, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.00	1.30	1.20	1.85	2.00	2.30	4.25	1.75	0.60	0.60	0.80	[illegible]
2	1.00	1.30	1.30	1.85	1.90	2.35	4.25	1.75	.55	.60	.80	[illegible]
3	1.00	1.30	1.30	1.85	1.85	2.45	4.10	1.70	.55	.60	.80	[illegible]
4	1.00	1.30	1.25	1.80	1.80	2.35	3.90	1.60	.55	.65	.80	[illegible]
5	1.00	1.20	1.20	1.90	1.75	2.45	3.70	1.60	.55	.65	.80	[illegible]
6	1.00	1.20	1.20	1.95	1.70	2.65	3.70	1.60	.55	.65	.80	[illegible]
7	1.00	1.25	1.20	2.15	1.65	2.90	3.70	1.60	.55	.65	.80	[illegible]
8	1.10	1.25	1.45	2.40	1.65	3.00	3.50	1.60	.55	.65	.80	[illegible]
9	1.10	1.35	1.55	2.30	1.65	3.10	3.40	1.50	.55	.70	.80	[illegible]
10	1.10	1.50	1.40	2.80	1.75	3.30	3.30	1.45	.55	.70	.80	[illegible]
11	1.10	1.80	1.30	2.80	2.00	3.65	3.25	1.40	.55	.70	.80	[illegible]
12	1.10	1.65	1.25	2.90	2.15	3.80	3.10	1.40	.55	.70	.80	[illegible]
13	1.20	1.65	1.25	2.90	2.35	4.60	3.00	1.30	.55	.70	.80	[illegible]
14	1.20	1.40	1.20	2.90	2.50	4.60	3.00	1.25	.55	.70	.85	[illegible]
15	1.20	1.50	1.20	2.90	2.65	4.40	2.90	1.20	.55	.70	.85	[illegible]
16	1.20	2.10	1.45	2.90	2.65	4.30	2.80	1.15	.55	.70	.85	[illegible]
17	1.20	2.15	1.45	2.90	2.55	4.40	2.70	1.10	.55	.70	.85	[illegible]
18	1.20	2.20	1.45	2.90	2.40	4.80	2.60	1.10	.55	.70	.90	[illegible]
19	1.20	2.10	1.50	2.70	2.30	5.20	2.60	1.10	.55	.70	.90	[illegible]
20	1.20	2.10	1.50	2.50	2.20	5.40	2.50	1.00	.55	.70	.90	[illegible]
21	1.20	1.80	1.50	2.45	2.20	5.65	2.50	1.00	.55	.70	.90	[illegible]
22	1.30	1.50	1.50	2.45	2.10	5.30	2.50	.95	.55	.75	.90	[illegible]
23	1.30	1.50	1.50	2.60	2.00	5.00	2.30	.90	.55	.80	.90	[illegible]
24	1.30	1.40	2.15	2.60	1.95	4.70	2.10	.90	.55	.80	.90	[illegible]
25	1.30	1.40	2.70	2.60	1.90	4.60	2.10	.85	.55	.80	.90	[illegible]
26	1.30	1.15	2.70	2.50	2.00	4.50	2.10	.80	.55	.85	.90	[illegible]
27	1.30	1.25	2.30	2.45	2.20	4.40	2.00	.75	.55	.85	.90	[illegible]
28	1.30	1.20	2.10	2.35	2.20	4.20	2.00	.70	.60	.85	.90	[illegible]
29	1.30	.....	2.10	2.10	2.15	4.20	2.00	.70	.60	.85	.90	[illegible]
30	1.30	.....	1.95	2.10	2.20	4.30	1.90	.65	.60	.85	.90	[illegible]
31	1.30	.....	1.85	.....	2.20	.....	1.80	.60	.....	.85	.....	

HUMBOLDT RIVER AT GOLCONDA, NEVADA.

gaging station at Golconda is located near the great northern f Humboldt River and below the central valley. It is about s above the mouth of Little Humboldt River. The station was ıhed by L. H. Taylor October 24, 1894, and has been main- continuously since that time. It is located 1¼ miles north of vn. The gage is vertical and spiked to posts driven into the ık of the river. Bench mark No. 1 is the top of a 2 by 4 inch iven flush with the ground surface 20 feet from the gage, and ı elevation of 10.55 feet above gage datum. Bench mark No. 2 op of a large spike driven into a post which is set firmly into ıund about 15 feet from the gage, and is 13.70 feet above gage

Measurements are made from cable and suspended car. The ıre moderately high, but liable to overflow at extreme high

The bed of the stream is of gravel and sand, somewhat shifting. ults of measurements may be found as follows: 1896, Eighteenth ı Report, Part IV, page 306; 1897, Nineteenth Annual Report, V, page 427; 1898, Twentieth Annual Report, Part IV, page The following measurements were made by L. H. Taylor in

April 29, gage height, 8.10 feet; discharge, 2,157 second-feet.
May 26, gage height, 7 feet; discharge, 1,440 second-feet.
June 30, gage height, 7.60 feet; discharge, 1,767 second-feet.
July 30, gage height, 6.30 feet; discharge, 1,058 second-feet.
August 25, gage height, 3.50 feet; discharge, 316 second-feet.
September 28, gage height, 1.05 feet; discharge, 37 second-feet.

ıily gage height, in feet, of Humboldt River at Golconda, Nevada, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	0.70	2.60	3.60	5.70	8.10	7.00	7.70	6.10	2.20	1.00	1.30	2.00
.....	.80	2.70	3.50	5.80	8.10	6.80	7.70	6.00	1.90	1.00	1.35	2.00
.....	.80	2.80	3.50	5.90	8.20	7.00	7.80	5.90	1.70	1.00	1.40	2.00
.....	.80	2.80	3.50	6.00	8.30	7.10	8.00	5.80	1.60	.95	1.50	2.05
.....	.80	2.80	3.50	6.10	8.20	7.05	8.00	5.50	1.50	.95	1.55	2.05
.....	.80	2.90	3.50	6.20	8.20	7.00	8.00	5.40	1.45	.95	1.60	2.05
.....	.80	2.90	3.50	6.30	8.20	7.00	8.00	5.30	1.40	.95	1.60	2.05
.....	.80	2.90	3.50	6.40	8.20	6.90	8.10	5.20	1.40	.90	1.65	2.05
.....	.80	2.90	3.60	6.40	8.20	6.90	8.10	5.00	1.40	.90	1.65	2.10
.....	.80	2.90	3.60	6.50	8.10	6.80	8.10	5.00	1.35	.90	1.70	2.10
.....	.80	2.90	3.60	6.60	8.00	6.70	7.90	4.90	1.35	.90	1.70	2.10
.....	.80	2.90	3.60	6.70	8.00	6.70	7.80	4.80	1.30	.90	1.70	2.10
.....	.80	3.10	3.60	6.70	8.00	6.60	7.70	4.80	1.30	.90	1.75	2.10
.....	.80	3.50	3.60	6.70	8.00	6.60	7.60	4.70	1.30	.90	1.75	2.15
.....	.80	3.60	3.60	6.70	8.00	6.50	7.60	4.60	1.25	.90	1.80	2.15
.....	.90	3.80	3.60	6.80	7.90	6.50	7.50	4.50	1.25	.90	1.80	2.15
.....	1.30	3.80	3.60	6.80	7.80	6.60	7.50	4.50	1.20	.95	1.85	2.15
.....	1.20	3.80	3.60	6.90	7.70	6.70	7.40	4.30	1.20	.95	1.85	2.15
.....	1.40	3.90	3.60	6.90	7.60	6.80	7.40	4.30	1.15	1.00	1.85	2.15
.....	1.50	3.90	3.60	7.50	7.50	6.90	7.30	4.20	1.15	1.00	1.90	2.15
.....	1.50	3.90	4.00	7.50	7.50	7.10	7.30	4.10	1.10	1.00	1.90	2.20
.....	1.50	3.90	4.40	7.50	7.40	7.30	7.00	4.00	1.10	1.05	1.90	2.20
.....	1.70	3.80	4.50	7.50	7.20	7.40	7.00	3.80	1.10	1.05	1.90	2.20
.....	1.80	3.70	4.50	7.60	7.20	7.50	6.90	3.60	1.05	1.10	1.95	2.20
.....	2.10	3.70	4.70	7.70	7.00	7.50	6.80	3.50	1.05	1.10	1.95	2.15
.....	2.50	3.70	4.70	7.80	7.00	7.70	6.80	3.30	1.05	1.15	1.95	2.15
.....	2.60	3.70	5.10	7.80	7.10	7.80	6.60	3.10	1.05	1.15	1.95	2.10
.....	2.60	3.70	5.40	7.90	7.20	7.70	6.50	2.90	1.05	1.20	2.00	2.10
.....	2.60	.....	5.70	8.10	7.20	7.60	6.40	2.70	1.05	1.20	2.00	2.15
.....	2.60	.....	5.70	8.10	7.30	7.60	6.30	2.60	1.05	1.25	2.00	2.15
.....	2.60	.....	5.70	.....	7.40	.....	6.20	2.40	.....	1.25	.....	2.20

HUMBOLDT RIVER AT OREANA, NEVADA.

On the lower reaches of this river measurements have been made for a number of years at Oreana, and the results show the amount of water available for storage at the possible reservoir sites in the vicinity of Humboldt Station, and also for the six canal systems now in operation below Oreana. The station, established by L. H. Taylor January 27, 1896, is located 1½ miles above the old Oreana highway bridge, 12 miles northeast of Lovelock, and above all the canals diverting water in the vicinity of that town. The gage rod is an inclined 2 by 4 inch pine timber, spiked to posts driven well into the bank of the river. The bench mark is a 10 by 10 inch post near the left bank of the stream, about 40 feet from the gage, and is at an elevation of 10 feet above gage datum. The station is provided with a cable and car. The river banks are high and not liable to overflow. The bed of the river is sandy and shifting. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 307; 1897, Nineteenth Annual Report, Part IV, page 428; 1898, Twentieth Annual Report, Part IV, page 439. The following measurements of discharge were made by L. H. Taylor during 1899:

June 29, gage height, 4.50 feet; discharge, 1,951 second-feet.
August 2, gage height, 3.60 feet; discharge, 1,214 second-feet.
August 30, gage height, 1.80 feet; discharge, 241 second-feet.
September 26, gage height, 1.20 feet; discharge, 100 second-feet.
October 27, gage height, 0.90 foot; discharge, 60 second-feet.

Daily gage height, in feet, of Humboldt River at Oreana, Nevada, for 1899.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	4.50	3.70	1.80	1.10	0.90	1.20
2	.....	4.50	3.60	1.70	1.10	.90	1.20
3	.....	4.55	3.50	1.70	1.05	.90	1.20
4	.....	4.55	3.30	1.70	1.05	.90	1.30
5	.....	4.55	3.20	1.60	1.05	.90	1.30
6	.....	4.60	3.20	1.60	1.00	.90	1.30
7	.....	4.60	3.10	1.60	1.00	.90	1.30
8	.....	4.60	3.00	1.50	1.00	1.00	1.30
9	.....	4.65	3.00	1.50	1.00	1.00	1.30
10	.....	4.70	2.90	1.50	.95	1.10	1.40
11	.....	4.70	2.90	1.50	.95	1.10	1.40
12	.....	4.70	2.80	1.50	.95	1.20	1.40
13	.....	4.80	2.80	1.45	.95	1.20	1.40
14	.....	4.80	2.70	1.45	.90	1.20	1.40
15	.....	4.90	2.60	1.40	.90	1.20	1.50
16	.....	4.90	2.60	1.40	.90	1.20	1.50
17	.....	4.90	2.50	1.40	.90	1.20	1.50
18	.....	5.00	2.50	1.35	.90	1.20	1.60
19	.....	5.00	2.40	1.35	.90	1.20	2.00
20	.....	5.00	2.40	1.30	.90	1.20	2.00
21	.....	5.00	2.30	1.30	.90	1.20	2.00
22	.....	4.90	2.20	1.30	.90	1.20	2.00
23	.....	4.70	2.10	1.25	.90	1.20	2.00
24	.....	4.55	2.10	1.25	.90	1.20	2.60
25	.....	4.30	2.00	1.20	.90	1.20	2.60
26	.....	4.10	2.00	1.20	.90	1.20	2.60
27	.....	3.95	2.00	1.20	.90	1.20	2.40
28	.....	3.85	1.90	1.15	.90	1.20	2.40
29	4.50	3.80	1.90	1.15	.90	1.20	2.40
30	4.50	3.90	1.80	1.10	.90	1.20	2.40
31	.....	3.80	1.80	.....	.90	.....	2.40

TRUCKEE RIVER AT NEVADA-CALIFORNIA STATE LINE.

This river has its source on the slopes of the Sierra Nevada in eastern California and flows northward, entering Lake Tahoe. This lake is at an elevation of 6,225 feet, and is the largest body of fresh water in the United States at this considerable altitude. The area of the lake itself is 193 square miles. As the State line between Nevada and California passes through the lake, a portion of it is in each State. The outlet of the lake is at Tahoe, California, and Truckee River from this point has a general northward course, receiving a number of important tributaries which contribute to its flow. There are a number of lakes at the head waters of the branch streams, which have been surveyed and recommended as reservoir sites. The drainage area is mapped on the Pyramid Peak, Truckee, Carson, and Markleeville atlas sheets of the United States Geological Survey. The basin is now partially included in the Lake Tahoe Forest Reserve, set apart by Executive proclamation of April 13, 1899. September 7, 1899, a station was established on this river by L. H. Taylor, at the State line, 17 miles west of Reno, Nevada. The gage is vertical, driven into the bed of the river and wired to a granite bowlder. The bench mark is the top of the rock to which the rod is fastened, and is at an elevation of 10 feet above gage datum. The channel is straight for a short distance above and below the station. The banks are not liable to overflow. The bed of the river is of gravel and cobbles and quite stable. One measurement of discharge was made by L. H. Taylor on September 7, 1899, when at a gage height of 2 feet a discharge of 303 second-feet was found.

Daily gage height, in feet, of Truckee River at Nevada-California State line, for 1899.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	.....	1.90	2.10	1.90	17	2.00	1.90	2.70	1.90
2	.....	1.90	2.10	1.90	18	1.90	1.90	2.50	1.90
3	.....	1.90	2.00	1.90	19	1.90	1.90	2.50	1.90
4	.....	1.90	2.00	1.90	20	1.90	2.40	2.30	1.90
5	.....	1.90	2.00	1.90	21	1.90	2.50	2.20	1.90
6	.....	1.90	2.60	1.80	22	1.90	2.70	2.10	1.90
7	2.00	1.90	2.80	1.80	23	1.90	2.50	2.00	1.90
8	2.00	1.90	3.20	1.80	24	2.00	2.40	2.00	1.90
9	1.90	1.90	3.80	1.90	25	1.90	2.30	2.00	1.90
10	1.90	1.90	4.00	1.90	26	1.90	2.20	2.00	1.90
11	1.90	1.90	4.20	1.90	27	1.90	2.10	2.00	1.90
12	1.90	2.00	3.50	1.90	28	1.90	2.00	2.00	1.90
13	1.90	2.00	3.00	2.00	29	1.90	2.00	1.90	1.90
14	1.90	2.00	2.70	2.00	30	1.90	2.10	1.90	1.90
15	1.90	1.90	2.90	2.00	31	.....	2.10	.....	1.90
16	2.10	1.90	2.70	1.90					

TRUCKEE RIVER AT VISTA, NEVADA.

On the lower courses of this river are located considerable stretches of irrigable land, which, however, have not yet been developed to their fullest extent. The drainage basin is peculiar in that its moun-

tainous collecting area is located in the State of California, while the lands which can be irrigated are situated in Nevada. This may lead in the future to certain legal difficulties, but not to the extent that it would if there were agricultural lands in both States. Truckee River after entering Nevada flows in a general easterly and then northerly direction, emptying into Pyramid Lake. The drainage area is mapped on the following atlas sheets of the United States Geological Survey: Pyramid Peak, Truckee, Markleeville, Carson, Reno, and Wadsworth. The station at Vista, Nevada, was established August 18, 1899, by L. H. Taylor, and is located 7 miles east of Reno, near the point where measurements were made in 1890, 1891, and 1892, the results of which are shown in the Thirteenth Annual Report, Part III, page 95. The rod is spiked to posts driven into the bed of the river. The bench mark is on a bluff of rocks 500 feet east of the gage, and is at an elevation of 17.50 feet above gage datum. Both banks are high and not liable to overflow. The bed is rocky and not subject to change. Three ditches diverting water from Truckee River above Reno were measured by L. H. Taylor on September 4, 1899, with the following results: Highland ditch, 6 miles above Reno, 4 miles below the head of ditch, discharge 16.7 second-feet; Maybury ditch at flume across Hunter Creek, 1 mile below head of ditch and 5 miles west of Reno, discharge 47 second-feet; Orr ditch at stone culvert under Southern Pacific Railroad, 1 mile below head of ditch, discharge 42 second-feet. Two measurements of discharge were made by L. H. Taylor during 1899, as follows: The first, on September 5, at a gage height of 2 feet, showed a discharge of 105 second-feet; the second measurement, on October 28, at a gage height of 2.75 feet, gave a discharge of 477 second-feet.

Daily gage height, in feet, of Truckee River at Vista, Nevada, for 1899.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.95	2.10	2.70	2.55	17	.....	2.15	2.60	3.50	2.90
2	.....	1.90	2.15	2.70	2.50	18	2.00	2.10	2.60	3.20	2.80
3	.....	2.00	2.15	2.60	2.60	19	2.10	2.10	2.50	3.10	2.80
4	.....	2.00	2.15	2.60	2.65	20	2.20	2.10	3.50	2.90	2.80
5	.....	2.00	2.15	2.60	2.60	21	2.00	2.10	3.90	2.80	2.60
6	.....	2.00	2.15	2.60	2.60	22	2.10	2.10	3.60	2.70	2.60
7	.....	2.00	2.15	2.70	2.60	23	2.00	2.10	3.00	2.60	2.60
8	.....	2.00	2.15	2.70	2.50	24	2.10	2.10	2.90	2.70	2.65
9	.....	2.05	2.15	2.80	2.50	25	2.05	2.10	2.80	2.70	2.65
10	.....	2.10	2.15	2.80	2.60	26	2.00	2.10	2.80	2.70	2.65
11	.....	2.05	2.15	3.00	2.60	27	2.00	2.10	2.80	2.70	2.70
12	.....	2.10	2.30	4.00	3.10	28	1.90	2.10	2.80	2.60	2.90
13	.....	2.10	2.50	3.70	2.90	29	1.95	2.10	2.80	2.55	3.20
14	.....	2.05	2.60	3.20	2.80	30	1.95	2.10	2.80	2.55	3.00
15	.....	2.15	2.50	3.20	3.25	31	1.90	.....	2.70	.....	3.00
16	.....	2.20	2.50	3.60	3.10						

BEAR RIVER AT BATTLECREEK, IDAHO.

This river has its source on the northern slope of the Uinta Mountains, in the northeastern part of Utah. Its general course is northerly, entering Wyoming at the southwestern corner of the State. It

ly afterwards swings back into Utah again and then reenters ning. After its junction with Smiths Fork it swings to the vard again, leaves Wyoming for the last time, and enters Idaho. ty-eight miles below the outlet of Bear Lake the river makes lden bend to the south, and its course is thence southerly, reen- g Utah and finally discharging its waters into Great Salt Lake. e are a number of reservoir sites in its upper basin, which have however, been examined in detail. Considerable irrigation is iced, commencing at a point where the river first enters Wyo- and thence extending downstream to the outlet of Bear Lake. e present time all of the low-water flow is thus utilized, result- n a scarcity during the latter part of the irrigation season. Lake acts as a regulator to the discharge of the portion of iver below it. The lake itself is one of the finest natural reser- sites in the country and could be utilized with small expense. it has not been utilized before this is due to the abundant water y of the lands below. The agricultural lands in Idaho adjacent s river are of small extent, and at the present time little water is ted; nor does it receive a large additional supply in this State, t in times of flood discharges. The gaging station at Battle- was established on October 11, 1889, and is located about 10 north of the Utah-Idaho boundary line. The measurements the amount of water of this river available for irrigation pur- in Cache Valley, Utah. The gage consisted of a vertical board l to a pile. This was carried away June 30, 1899, but was ced on August 4 by a wire and weight, readings being made horizontal scale. The bench mark for the old gage is described in r-Supply Paper No. 16, page 157. It was a nail in the southeast r of a house near the gage, about 1.5 feet from the ground 10.95 feet above gage datum. The bench mark for the present is a mark of black paint on the top of a log projecting from outheast corner of the observer's house, about 2 feet above the ce of the ground and 11.118 feet above gage datum. The station ipped with a cable and car. The results of measurements may und as follows: 1896, Eighteenth Annual Report, Part IV, page 1897, Nineteenth Annual Report, Part IV, page 432; 1898, tieth Annual Report, Part IV, page 459. The following meas- ents of discharge were made by J. S. Baker and G. L. Swendsen g 1899:

March 28, gage height, 1.75 feet; discharge, 773 second-feet.
May 8, gage height, 3.25 feet; discharge, 2,376 second-feet.
July 3, gage out; discharge, 4,781 second-feet.
August 4, gage height, 3.01 feet; discharge, 1,732 second-feet.
December 4, gage height, 2.21 feet; discharge, 1,312 second-feet.

Daily gage height, in feet, of Bear River at Battlecreek, Idaho, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.60	1.60	1.50	1.90	3.50	4.10	.....	2.10	2.00	2.20	2.20
2	1.60	1.60	1.50	1.90	3.50	4.10	.....	2.10	2.00	2.20	2.20
3	1.60	1.60	1.50	2.00	3.40	4.10	.....	.....	2.00	2.20	2.20
4	1.60	1.60	1.50	2.00	3.40	4.10	3.10	.....	2.00	2.20	2.20
5	1.60	1.60	1.50	2.15	3.40	4.10	3.00	.....	2.00	2.20	2.10
6	1.60	1.60	1.50	2.15	3.30	4.15	3.00	.....	2.00	2.20	2.10
7	1.60	1.60	1.50	2.15	3.20	4.20	2.90	.....	2.00	2.20	2.00
8	1.60	1.60	1.50	2.25	3.20	4.20	2.90	.....	2.00	2.20	1.90
9	1.60	1.60	1.50	2.60	3.30	4.20	2.90	.....	2.00	2.20	1.90
10	1.60	1.60	1.50	2.85	3.40	4.25	2.90	2.10	2.00	2.20	1.80
11	1.60	1.60	1.50	2.90	3.40	4.30	2.90	2.10	2.00	2.20	1.70
12	1.60	1.60	1.50	3.10	3.50	4.30	2.90	2.10	2.00	2.40	2.30
13	1.60	1.60	1.50	3.45	3.60	4.30	2.90	2.10	2.15	2.40	2.20
14	1.60	1.60	1.50	3.55	3.60	4.40	2.90	2.10	2.20	2.40	2.20
15	1.60	1.60	1.50	3.60	3.60	4.40	2.80	2.10	2.20	2.40	2.10
16	1.60	1.60	1.50	3.50	3.60	4.40	2.80	2.10	2.20	2.40	2.10
17	1.60	1.60	1.50	3.50	3.60	4.40	2.70	2.10	2.20	2.40	2.10
18	1.60	1.50	1.50	3.40	3.70	4.40	2.70	2.10	2.20	2.40	2.00
19	1.60	1.50	1.50	3.45	3.80	4.40	2.60	2.10	2.20	2.40	2.00
20	1.60	1.50	1.60	3.30	3.80	4.40	2.60	2.10	2.20	2.40	2.00
21	1.60	1.50	1.60	3.30	3.80	4.40	2.50	2.10	2.20	2.30	1.90
22	1.60	1.50	1.60	3.30	3.80	4.50	2.50	2.10	2.30	2.30	1.90
23	1.60	1.50	1.60	3.40	3.80	4.50	2.40	2.10	2.30	2.30	1.90
24	1.60	1.50	1.65	3.40	3.80	4.50	2.30	2.00	2.30	2.30	1.90
25	1.60	1.50	1.90	3.40	3.90	4.60	2.30	2.00	2.30	2.30	1.90
26	1.60	1.50	1.90	3.45	3.90	4.60	2.30	2.00	2.30	2.20	1.90
27	1.60	1.50	1.80	3.50	3.90	4.60	2.20	2.00	2.30	2.20	1.90
28	1.60	1.50	1.80	3.50	3.90	4.60	2.20	2.00	2.30	2.20	1.90
29	1.60	.....	1.80	3.50	4.00	4.70	2.20	2.00	2.20	2.20	1.90
30	1.60	.....	1.80	3.50	4.00	.....	2.20	2.00	2.20	2.20	1.90
31	1.60	.....	1.80	.....	4.00	.....	2.20	.....	2.20	.....	.....

From June 29 to August 4 no readings; gage out.

LOGAN RIVER AT LOGAN, UTAH.

This river rises in the elevated region west of Bear Lake and flows in a general southwesterly direction until it enters Cache Valley, when it bends northward and enters Bear River before this stream reaches its lower canyon. Logan River has a good water supply, and as soon as it appears from its canyon a number of canals divert its waters for the irrigation of a large portion of Cache Valley. The station on Logan River was established June 1, 1896, and is located in the river canyon about 2 miles east of Logan, Utah. One gage is a vertical iron post, set firmly in the middle of the river's bed and graduated to feet and tenths. A second gage rod is a wooden post driven into the ground near the north bank of the river. The bench mark for both rods is a stone 35 feet northeast of the end of the cable on the north side of the river, and is at an elevation of 14.01 feet above gage datum. It is marked by a cross chiseled on the rock and by the letters "B. M." in red paint. The equipment consists of a cable and car. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 316; 1897, Nineteenth Annual Report, Part IV, page 434; 1898, Twentieth Annual Report, Part IV, page 462. The following discharge measurements were made by J. S. Baker and G. L. Swendsen during 1899:

Discharge measurements of Logan River at Logan, Utah.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
April 22	3.10	620	July 3	4.60	1,526
May 9	3.57	628	August 5	3.52	525
May 15	3.67	750	November 1	2.82	323
May 29	3.80	931	December 2	2.75	301
June 17	4.65	1,630			

Daily gage height, in feet, of Logan River at Logan, Utah, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.55	2.50	2.50	2.55	3.05	3.70	4.75	3.55	3.10	2.90	2.80	2.75
2	2.50	2.50	2.50	2.55	3.00	3.75	4.70	3.50	3.10	2.90	2.80	2.75
3	2.50	2.50	2.45	2.55	3.00	3.80	4.65	3.50	3.10	2.90	2.80	2.75
4	2.45	2.35	2.45	2.55	3.00	4.20	4.60	3.50	3.05	2.90	2.80	2.70
5	2.45	2.30	2.45	2.60	3.10	4.45	4.50	3.50	3.05	2.90	2.80	2.75
6	2.45	2.80	2.40	2.60	3.15	4.25	4.45	3.50	3.05	2.90	2.80	2.75
7	2.50	2.50	2.45	2.65	3.20	4.15	4.40	3.50	3.05	3.90	2.80	2.75
8	2.55	2.50	2.50	2.65	3.30	4.15	4.35	3.45	3.05	2.90	2.80	2.75
9	2.50	2.50	2.50	2.75	3.65	4.20	4.30	3.40	3.05	2.90	2.80	2.75
10	2.50	2.50	2.50	2.85	3.50	4.30	4.25	3.40	3.05	2.90	2.80	2.75
11	2.50	2.50	2.45	3.00	3.60	4.50	4.20	3.35	3.00	2.90	2.80	2.75
12	2.50	2.50	2.45	3.00	3.80	4.75	4.20	3.35	3.00	2.90	2.80	2.70
13	2.50	2.50	2.45	3.00	3.75	4.65	4.15	3.35	3.00	2.90	2.80	2.70
14	2.50	2.50	2.45	3.05	3.70	4.50	4.15	3.30	3.00	2.90	2.80	2.70
15	2.50	2.50	2.45	3.05	3.65	4.45	4.10	3.30	3.00	2.90	2.80	2.70
16	2.50	2.50	2.45	3.05	3.55	4.50	4.05	3.30	3.00	2.90	2.80	2.70
17	2.50	2.45	2.45	3.05	3.50	4.65	4.00	3.25	3.00	2.90	2.80	2.70
18	2.50	2.45	2.45	3.00	3.60	4.70	4.00	3.25	3.00	2.90	2.75	2.70
19	2.50	2.45	2.45	2.95	3.65	4.90	3.95	3.20	2.95	2.90	2.75	2.65
20	2.50	2.45	2.50	2.95	3.70	5.00	3.90	3.20	2.95	2.90	2.75	2.65
21	2.50	2.45	2.50	2.95	3.60	4.85	3.85	3.20	2.95	2.90	2.75	2.60
22	2.50	2.40	2.50	3.10	3.50	4.80	3.80	3.20	2.95	2.85	2.75	2.60
23	2.40	2.35	2.50	3.30	3.55	4.75	3.80	3.15	2.95	2.85	2.75	2.75
24	2.50	2.45	2.50	3.40	3.65	4.70	3.75	3.15	2.95	2.85	2.75	2.70
25	2.50	2.45	2.65	3.30	3.70	4.70	3.75	3.15	2.95	2.85	2.75	2.70
26	2.50	2.45	2.65	3.25	3.75	4.70	3.70	3.15	2.95	2.85	2.75	2.70
27	2.50	2.45	2.60	3.20	3.85	4.65	3.70	3.10	2.90	2.85	2.75	2.70
28	2.50	2.45	2.60	3.10	3.75	4.65	3.65	3.10	2.90	2.85	2.75	2.65
29	2.50	.....	2.60	3.05	3.75	4.70	3.65	3.10	2.90	2.85	2.75	2.70
30	2.50	.....	2.60	3.10	3.80	4.75	3.60	3.10	2.90	2.80	2.75	2.70
31	2.50	.....	2.55	.....	3.70	.....	3.55	3.10	.....	2.80	.....	2.70

BEAR RIVER AT COLLINSTON, UTAH.

After entering the northern end of Cache Valley this river receives a umber of important tributaries, viz. Cub Creek, Logan River, Black-ıith Fork, and Little Bear River. Below the mouth of Logan River, ear River has cut through the northern extension of the Wasatch ange, forming what is known as its lower canyon. On its appearance om this it turns southerly and enters Great Salt Lake. A large canal as in process of construction during 1899, and next year a consider-le portion of the summer flow of Bear River will be diverted by it irrigate lands on the west side of Cache Valley. One of the most table irrigation enterprises of the country diverts water from Bear ver in the lower canyon and irrigates land principally to the west-ırd of Malade River, the lowest of the important tributaries of Bear ver. The gaging station at Collinston was established in July, 1889, d is located about 4 miles from the railroad station at Collinston, 2 iles east of the town of Fielding, Utah, and below the headworks of

the Bear River canal. The gage consists of a vertical iron rod graduated to tenths of a foot. The bench mark is a nail in an oak post 20 feet west of the gage and 20 feet north of the cable, and is at an elevation of 7.35 feet above gage datum. The equipment consists of a cable, tagged wire, and a boat. The observer is generally the ditch rider of the Bear River Canal Company, who has a house near the station. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 320; 1897, Nineteenth Annual Report, Part IV, page 435; 1898, Twentieth Annual Report, Part IV, page 460. The following measurements of discharge were made during 1899:

May 5, gage height, 4 feet; discharge, 4,438 second-feet.
June 23, gage height, 5.60 feet; discharge, 6,653 second-feet.
July 14, gage height, 4.61 feet; discharge, 4,819 second-feet.
November 29, gage height, 2.40 feet; discharge, 2,083 second-feet.

Daily gage height, in feet, of Bear River at Collinston, Utah, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.30	1.90	2.00	2.60	4.40	4.90	5.60	3.00	2.00	1.80	2.40	2.40
2	1.50	1.90	2.00	2.60	4.30	4.90	5.40	3.00	2.00	1.90	2.30	2.40
3	1.50	1.90	1.90	2.60	4.20	4.90	5.50	2.90	1.90	1.90	2.40	2.40
4	1.50	1.40	1.90	2.60	4.20	4.90	5.50	2.90	1.90	1.90	2.30	2.30
5	1.70	1.40	1.90	2.60	4.20	4.90	5.40	3.00	2.00	1.90	2.30	2.20
6	1.70	1.40	1.90	2.60	4.10	5.10	5.40	3.00	1.90	1.90	2.30	2.20
7	1.70	1.40	1.90	2.70	4.10	5.30	5.40	2.90	1.80	1.90	2.30	2.10
8	1.70	1.40	1.90	2.80	4.20	5.30	5.30	2.90	1.80	1.90	2.30	2.00
9	1.70	1.40	2.10	2.90	4.10	5.30	5.20	2.90	1.60	1.90	2.30	2.00
10	1.70	1.60	2.10	3.00	4.20	5.20	5.10	2.90	2.00	1.90	2.40	2.00
11	1.70	1.60	2.10	3.60	4.40	5.20	5.00	2.90	2.00	2.00	2.40	2.20
12	1.70	1.60	2.00	3.60	4.70	5.30	4.90	2.80	1.90	2.20	2.50	2.00
13	1.70	1.80	2.00	3.80	4.80	5.40	4.80	2.80	1.90	2.20	2.50	1.90
14	1.70	1.80	2.00	4.10	4.90	5.50	4.70	2.80	1.90	2.30	2.50	2.10
15	1.70	1.80	2.10	4.50	5.10	5.60	4.60	2.80	1.80	2.40	2.50	2.20
16	1.80	1.70	2.10	4.50	5.10	5.50	4.50	2.70	1.90	2.30	2.50	2.20
17	1.80	1.70	2.20	4.50	5.20	5.50	4.40	2.60	1.90	2.50	2.60	2.20
18	1.80	1.70	2.40	4.40	5.20	5.50	4.30	2.40	1.90	2.50	2.60	2.20
19	1.80	1.70	2.40	4.20	5.00	5.40	4.20	2.40	1.90	2.50	2.60	2.20
20	1.80	1.70	2.40	4.10	4.80	5.50	4.10	2.40	2.00	2.50	2.60	2.10
21	1.80	1.80	2.40	4.10	4.80	5.50	4.00	2.30	1.90	2.50	2.50	2.00
22	1.80	1.80	2.40	4.10	4.80	5.60	3.80	2.20	1.90	2.40	2.50	1.90
23	1.80	1.80	2.40	4.20	4.80	5.60	3.70	2.20	1.90	2.40	2.50	2.00
24	1.80	1.80	2.50	4.30	4.70	5.60	3.60	2.30	1.90	2.50	2.50	2.00
25	1.80	1.80	2.50	4.40	4.70	5.60	3.60	2.20	1.90	2.50	2.40	1.90
26	1.80	1.90	2.50	4.50	4.80	5.60	3.50	2.20	1.80	2.50	2.40	2.00
27	1.80	1.90	2.50	4.50	4.80	5.60	3.40	2.10	1.60	2.50	2.40	2.10
28	1.90	2.00	2.60	4.50	4.90	5.50	3.40	2.10	1.70	2.40	2.40	2.10
29	1.90	.....	2.60	4.50	4.90	5.60	3.30	2.10	1.70	2.40	2.40	2.20
30	1.90	.....	2.60	4.40	4.90	5.60	3.20	2.10	1.70	2.40	2.40	2.20
31	1.90	.....	2.60	.....	4.90	.....	3.10	2.00	.....	2.40	.....	2.20

OGDEN RIVER AT OGDEN, UTAH.

This river rises in the high land to the east of the Wasatch Range and flows in a general southerly direction. Passing through the Wasatch Mountains in a picturesque canyon, and appearing on the plains in the vicinity of Ogden, it shortly enters Weber River, and thus finds its way into Great Salt Lake. The present station was established in the spring of 1897, and is located at the old powder mill in the canyon, 5 miles east of Ogden and about 5 miles below the headworks of the Pioneer Electric Power Company; therefore the results do not show the amount of water used by that company. The gage is inclined and

vided into tenths of a foot. On June 22 the dam below the gage as washed out and the daily readings were not continued after that te. On June 30, 1899, the gage itself was carried away, but was established on August 26. The bench mark of the new gage is the p of a large quartzite bowlder on the south side of the wagon road, bout 60 feet southwest of the south end of the cable, and is at an eleation of 12.642 feet above gage datum. The results of measurements ay be found as follows: 1896, Eighteenth Annual Report, Part IV, age 321; 1897, Nineteenth Annual Report, Part IV, page 437; 1898, wentieth Annual Report, Part IV, page 465. The following measrements of discharge were made by W. B. Dougall and J. S. Baker 1 1899:

May 2, gage height, 1.70 feet; discharge, 1,008 second-feet.[1]
May 4, gage height, 1.25 feet; discharge, 833 second-feet.
June 30, gage out; discharge, 396 second-feet.
July 12, gage height, 2.38 feet; discharge, 221 second-feet.
August 26, gage height, 1.25 feet; discharge, 72 second-feet.

Daily gage height, in feet, of Ogden River at Ogden, Utah, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	1.40	1.50	2.50	3.80	1.90	1.40	17	1.60	1.60	2.00	3.10	2.60	1.40
2	1.90	1.70	2.40	3.80	1.80	2.50	18	1.70	1.70	2.20	3.00	2.50	1.10
3	1.50	1.70	2.10	3.50	1.70	2.40	19	1.60	1.80	2.30	2.70	2.60	1.00
4	1.50	1.60	2.00	3.50	1.50	2.70	20	1.60	1.80	2.40	2.40	2.70	.80
5	1.50	1.50	2.10	3.80	1.50	2.80	21	1.60	1.90	2.60	2.30	2.40	.70
6	1.55	1.40	2.00	4.10	1.90	2.60	22	1.70	1.90	2.50	2.80	2.50	.....
7	1.60	1.40	2.00	4.10	2.10	2.40	23	1.70	1.80	2.60	3.00	2.60	.....
8	1.60	1.40	2.00	4.50	2.80	2.20	24	1.50	1.80	3.70	3.50	2.80	.....
9	1.50	1.40	2.00	4.50	3.20	2.20	25	1.70	1.80	4.10	3.50	2.50	.....
10	1.50	1.40	2.10	4.90	3.30	2.30	26	1.70	1.80	4.30	3.10	2.50	.....
11	1.50	1.50	1.90	4.70	3.50	2.30	27	1.70	1.80	3.90	2.80	2.40	.....
12	1.50	1.60	2.10	4.00	3.60	2.70	28	1.70	1.90	3.70	2.60	2.20	.....
13	1.50	1.50	2.10	4.25	3.60	2.60	29	1.80	.....	3.55	2.30	2.00	.....
14	1.40	1.50	2.10	4.00	3.50	2.40	30	1.70	.....	3.55	2.10	1.70	.....
15	1.70	1.50	2.00	3.40	2.90	1.80	31	1.70	.....	3.50	.....	1.60	.....
16	1.70	1.50	2.00	3.40	2.60	1.20							

Dam below washed out June 22.

WEBER RIVER AT UINTA, UTAH.

This river, like Ogden River, rises in the high country east of the Vasatch Mountains, passes through this range, and appears in the lains region in the vicinity of Ogden, where, after it receives the aters of Ogden River, it discharges into Great Salt Lake. There are number of good reservoir sites on its upper tributaries, and within ie last few years some of them have been utilized by the construction f notable storage works. The gaging station, established in October, 399, is located in the canyon 5 miles east of Uinta, on the Union acific Railroad, immediately above the narrows known as Devils ate. The gage is vertical, and is supported from above by a proecting timber placed out of reach of high water. The bench mark onsists of a spike driven into the first telegraph pole in the canyon oove the gage, and is at an elevation of 17.44 feet above gage

[1] At old powder-mill dam.

atum. The equipment consists of a cable, car, and tagged wire. The esults of measurements may be found as follows: 1896, Eighteenth nnual Report, Part IV, page 324; 1897, Nineteenth Annual Report, 'art IV, page 440; 1898, Twentieth Annual Report, Part IV, page 66. The following measurements of discharge were made by W. B.)ougall and J. S. Baker during 1899:

May 3, gage height, 3.20 feet; discharge, 1,857 second-feet.
May 6, gage height, 3.30 feet; discharge, 1,969 second-feet.
July 1, gage height, 4.10 feet; discharge, 2,582 second-feet.
July 10, gage height, 2.80 feet; discharge, 1,284 second-feet.

Daily gage height, in feet, of Weber River at Uinta, Utah, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	1.70	1.70	1.80	2.80	4.60	4.60	4.10	1.70	1.60	1.50
2	1.70	1.70	1.80	2.80	4.75	4.75	4.00	1.70	1.50	1.50
3	1.70	1.70	1.80	2.80	5.00	4.80	3.65	1.70	1.50	1.50
4	1.70	1.70	1.80	3.05	5.15	5.05	3.50	1.70	1.50	1.50
5	1.70	1.70	1.80	3.30	5.50	5.25	3.50	1.70	1.50	1.50
6	1.70	1.70	1.80	3.50	5.75	5.50	3.30	1.70	1.50	1.50
7	1.70	1.70	1.80	3.60	5.75	5.80	3.20	1.70	1.50	1.50
8	1.70	1.70	1.80	3.75	5.55	5.80	3.00	1.70	1.50	1.50
9	1.70	1.70	1.80	3.90	5.55	5.80	2.80	1.70	1.50	1.60
10	1.70	1.70	1.80	4.15	5.90	5.85	2.80	1.70	1.50	1.65
11	1.70	1.70	1.80	4.85	6.30	5.95	2.70	1.70	1.50	1.70
12	1.70	1.80	1.80	5.00	6.50	6.25	2.60	1.70	1.50	1.75
13	1.70	1.80	1.80	5.10	6.35	6.30	2.60	1.80	1.50	1.80
14	1.70	1.80	1.80	5.15	5.90	5.85	2.60	1.70	1.50	1.80
15	1.70	1.80	1.80	4.95	5.50	5.35	2.50	1.70	1.50	1.80
16	1.70	1.80	1.80	4.80	5.05	5.25	2.50	1.60	1.50	.....
17	1.70	1.80	1.80	4.75	4.65	5.40	2.45	1.60	1.50	.....
18	1.70	1.80	1.90	4.60	4.40	5.50	2.30	1.60	1.50	.....
19	1.70	1.80	1.90	4.00	4.30	5.80	2.30	1.60	1.50	.....
20	1.70	1.80	1.90	3.50	4.30	6.15	2.30	1.60	1.50	.....
21	1.70	1.80	1.90	3.40	4.55	6.30	2.20	1.60	1.50	.....
22	1.70	1.80	1.90	3.40	4.70	5.90	2.00	1.60	1.50	.....
23	1.70	1.80	2.10	4.80	4.85	5.15	2.00	1.60	1.50	.....
24	1.70	1.80	2.50	5.15	4.80	4.80	1.90	1.60	1.50	.....
25	1.70	1.80	3.15	5.35	5.15	4.65	1.80	1.60	1.50	.....
26	1.70	1.80	3.10	5.00	5.30	4.60	1.80	1.60	1.50	.....
27	1.70	1.80	2.85	4.30	5.25	4.35	1.80	1.60	1.50	.....
28	1.70	1.80	2.80	4.30	4.95	4.35	1.70	1.60	1.50	.....
29	1.70	.....	2.80	4.30	4.65	4.20	1.70	1.60	1.50	.....
30	1.70	.....	2.80	4.45	4.60	4.20	1.70	1.60	1.50	.....
31	1.70	.....	2.80	.....	4.60	.....	1.70	1.60	.....	.....

Station discontinued October 15.

PROVO RIVER AT PROVO, UTAH.

This river rises on the western slope of the Uinta Mountains and after receiving a number of tributaries enters what is known as Heber Valley, where considerable irrigation is practiced. After crossing this valley it passes through the Wasatch Mountains in a picturesque canyon, finally entering Utah Valley, where its summer flow is completely diverted for irrigation purposes. Its flood waters discharge into Utah Lake. The gaging station, established July 27, 1889, is located in the canyon, about 6 miles from Provo and above the head of most of the irrigation canals of Utah Valley. The diversion works of the company which develop power at the mouth of Provo Canyon for electric transmission to the mines west of Provo, are located about 5 miles above the station. The gage is inclined and fastened to stakes set in the ground. The bench mark is a stone firmly bedded in the

: near the wagon road, about 100 feet southwest of the gage. It ırked "B. M." in black paint, and is 6.95 feet above gage datum. channel is straight for some distance above and below the station. bed of the river is gravel and not liable to change. The equip- ; consists of a cable, car, and tagged wire. The results of meas- ıents may be found as follows: 1896, Eighteenth Annual Report, IV, page 226; 1897, Nineteenth Annual Report, Part IV, page 1898, Twentieth Annual Report, Part IV, page 468. The follow- neasurements of discharge were made by W. B. Dougall and J. S. ır in 1899:

May 8, gage height, 4.70 feet; discharge, 496 second-feet.
June 29, gage height, 6.70 feet; discharge, 1,745 second-feet.
July 13, gage height, 5.22 feet; discharge, 535 second-feet.
August 16, gage height, 4.69 feet; discharge, 340 second-feet.
September 4, gage height, 4.60 feet; discharge, 352 second-feet.

Daily gage height, in feet, of Provo River at Provo, Utah, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	4.20	4.20	4.30	4.90	5.20	5.80	6.50	4.60	4.60	4.80
2	4.20	4.20	4.30	4.80	5.20	5.80	6.90	4.60	4.60	4.80
3	4.20	4.20	4.30	4.80	5.20	5.80	6.30	4.60	4.60	4.80
4	4.20	4.20	4.30	4.80	5.20	6.20	6.20	4.60	4.60	4.80
5	4.20	4.00	4.30	4.80	5.20	6.40	6.10	4.60	4.60	4.80
6	4.20	4.00	4.30	4.80	5.20	6.70	5.90	4.60	4.60	4.80
7	4.20	4.00	4.30	4.70	4.80	6.70	5.70	4.60	4.60	4.80
8	4.20	4.00	4.30	4.70	4.90	6.80	5.60	4.60	4.60	4.80
9	4.20	4.00	4.30	4.90	5.00	6.80	5.50	4.70	4.60	4.80
10	4.20	3.90	4.30	4.90	5.30	6.90	5.40	4.70	4.60	4.80
11	4.20	3.90	4.40	5.00	5.40	7.10	5.30	4.70	4.60	4.80
12	4.20	4.20	4.40	5.00	5.70	7.10	5.20	4.70	4.60	4.80
13	4.20	4.20	4.40	5.00	5.70	7.10	5.20	4.70	4.60	4.80
14	4.20	4.20	4.40	5.10	5.70	7.20	5.20	4.70	4.60	4.80
15	4.20	4.20	4.40	5.10	5.70	7.20	5.20	4.70	4.60	4.80
16	4.20	4.20	4.40	5.10	5.60	7.20	5.10	4.70	4.60	4.80
17	4.20	4.20	4.50	5.10	5.50	7.20	5.10	4.70	4.60	4.80
18	4.20	4.20	4.50	5.10	5.50	7.60	5.10	4.70	4.60	4.80
19	4.20	4.20	4.80	5.20	5.50	7.70	5.00	4.70	4.60	4.80
20	4.20	4.20	5.00	5.20	5.50	7.80	5.00	4.60	4.60	4.80
21	4.20	4.20	5.00	5.30	5.50	7.90	5.00	4.60	4.60	4.80
22	4.20	4.20	5.00	5.30	5.30	8.00	5.00	4.60	4.60	.....
23	4.20	4.20	5.00	5.30	5.30	7.60	4.90	4.60	4.60	.....
24	4.20	4.20	5.30	5.30	5.30	7.60	4.90	4.60	(a)	.....
25	4.20	4.20	5.30	5.30	5.60	7.40	4.90	4.60	(a)	.....
26	4.20	4.20	5.00	5.30	5.80	7.40	4.80	4.60	(a)	.....
27	4.20	4.20	5.00	5.20	5.80	7.20	4.80	4.60	(a)	.....
28	4.20	4.20	5.00	5.20	5.80	7.10	4.80	4.60	(a)	.....
29	4.20	.....	5.00	5.20	5.80	6.70	4.80	4.60	(a)	.....
30	4.20	.....	5.00	5.20	5.80	6.60	4.60	4.60	(a)	.....
31	4.20	.....	5.00	.....	5.80	.....	4.60	4.60	.....	.....

a No reading. Station discontinued October 21.

UTAH LAKE.

ıis fresh-water lake receives the surplus waters and seepage of a ber of streams that receive their water supply from the Wasatch ntains, the principal ones being Currant Creek, Spanish Fork, ɔle Creek, Provo River, and American Fork. The ordinary flow ıese streams is diverted, on their appearance from their canyons, rigate the lands of Utah Valley. A gaging station has been tained on Provo River, as described on page 338 of this report. mber of miscellaneous measurements were made during 1899 on

the other tributaries as well as on the canals diverting water fr
same during the last season. On May 11 Spanish Fork, at the
bridge in the canyon, was discharging 679 second-feet; May 10, 1
Creek, at the second bridge in the canyon, above Springville, w
charging 244 second-feet; American Fork, on May 9, was ca
106 second-feet, with a gage height of 0.1 foot, on a temporar
established that day. The following table shows the discharg
number of canals in Utah County as determined by J. S. Baker

Discharge of canals in Utah County, Utah.

1899.

Date.	Stream.	Source.	Discharge.	Remari
			Sec.-feet.	
June 22	Boxelder Creek	Mountain springs	31.46	
Aug. 16	Timpanogas canal	Provo River	10.40	
Aug. 16	Timpanogas canal	Provo River	7.84	9,500 feet l
Aug. 17	Little Dry Creek canal.	Provo River	4.64	last mea ment.
Aug. 17	Tanner's race	Provo River	16.94	
Aug. 17	Lake Bottom canal	Provo River	7.14	
Aug. 17	West Union canal	Provo River	55.98	
Aug. 17	Provo Bench canal	Provo River	53.65	
Aug. 17	Provo Bench canal	Provo River	57.96	1½ miles a
Aug. 17	Park & Nuttall's ditch.	Provo River	11.84	last mea ment.
Aug. 17	Upper East Union canal.	Provo River	28.27	
Aug. 17	Upper East Union canal.	Provo River	27.52	1 mile belo measuren
Aug. 18	City race	Provo River	12.40	
Aug. 18	Factory race	Provo River	51.44	
Aug. 18	East Union canal	Provo River	18.22	
Aug. 18	Bomb & Richardson's canal.	Provo River	1.00	Estimated.
Aug. 18	Stubbs & Furgeson's canal.	Provo River	5.00	By floats.
Aug. 18	Richmond & Penrod's canal.	Provo River	4.00	Estimated.
Aug. 21	Mapleton Union canal.	Hobble Creek	19.11	
Aug. 21	Mapleton Union canal.	Hobble Creek	17.95	1 mile abov measuren
Aug. 21	Mapleton reservoir canal.	Hobble Creek	3.09	
Aug. 21	Mapleton reservoir canal.	Hobble Creek	2.73	One-half above measurem
Aug. 21	North Bench canal	Hobble Creek	8.35	
Aug. 21	North Bench canal	Hobble Creek	8.39	Three-fou mile belo measurem
Aug. 21	Island canal	Hobble Creek	4.02	
Aug. 21	Sage Creek canal	Hobble Creek	5.96	
Aug. 21	South Big Field ditch	Hobble Creek	5.52	
Aug. 21	City ditch	Hobble Creek	2.21	
Aug. 22	City canal	Spanish Fork	38.51	
Aug. 22	Salem Irrigation Company's canal.	Spanish Fork	22.05	
Aug. 22	South Field Irrigation Company's canal.	Spanish Fork	37.39	

Discharge of canals in Utah County, Utah—Continued.

1899—Continued.

ate.	Stream.	Source.	Discharge.	Remarks.
			Sec.-feet.	
g. 22	East Bench canal...	Spanish Fork.....	28.19	
g. 22	Lake Shore canal...	Spanish Fork.....	12.43	
g. 22	Salem Pond canal...	Low springs.....	4.99	
g. 23	Summit Creek.....	Mountain springs..	14.64	
g. 23	Spring Lake Creek..	Low springs.....	2.89	
g. 25	American Fork canal.	American Fork....	28.85	
g. 25	Lehi canal.....	American Fork....	17.82	
g. 25	Pleasant Grove canal	American Fork....	10.71	

NOTE.—All measurements were made by current meter unless otherwise stated.

station has been maintained on Utah Lake at Geneva, where been recorded the rise and fall of the water surface since Novem- 6, 1896. The gage consists of a vertical rod attached to one of a bath house at that point. The bench mark of the lake missioners, a sandstone monument at the edge of the bluff oppo- the south end of the pavilion, is 18.644 feet above gage datum, ch was placed 4 feet below compromise point. The results of rvations at this station will be found as follows: 1896, Eighteenth ual Report, Part IV, page 330; 1897, Nineteenth Annual Report, t IV, page 443; 1898, Twentieth Annual Report, Part IV, page 467.

Daily gage height, in feet, of Utah Lake at Geneva, Utah, for 1899.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	0.60	0.80		1.50			1.70		
2									0.60
3			1.30			2.25			
4	.65	.85		1.50				1.05	
5					1.70	2.00	1.50		
6	.65	.90	1.35	1.55				.95	
7							1.50		.30
8			1.35	1.50	1.85	2.15			
9	.60	.95						1.00	
0			1.35	1.50	1.90	2.10	1.55		.10
1	.60	1.00						.90	
2						2.10	1.50		
3	.65	1.00	1.40	1.55					
4					2.00		1.40	.90	.20
5	.70		1.45			2.00			
6		1.00						.80	
7			1.40		2.10	1.90	1.40		
8	.70	1.05						.80	
9					2.20		1.30		
0		1.05	1.40	1.55					
1					2.15		1.25		
2			1.45	1.60		1.80			
3		1.05						.75	
4			1.45	1.60		1.80	1.20		
5	.70							.70	
6					2.20		1.15		
7	.75		1.50	1.70				.70	
8							1.10		
9		1.25	1.50	1.65		1.75			
0					2.20			.65	
1		1.30		1.65			1.10		

Station discontinued October 14.

JORDAN RIVER.

Utah Lake discharges toward the north through Jordan River, which empties into Great Salt Lake. A number of large canals divert the waters of this stream and supply lands in Salt Lake County, one of them taking water to Salt Lake City. Measurements of the flow of Jordan River and the amount diverted into the canals have not been made systematically, owing largely to conservatism or distrust. When the hydrographic investigations were begun in 1889, an attempt was made on behalf of the Geological Survey to secure cooperation, or at least the sympathy of the persons interested, but there appeared to be a sentiment against obtaining records of this character, due possibly to the fear that private interests might be injured. There was a tacit agreement at least that it was better not to meddle with the systems in vogue. Even ten years later, when attempts were made by the city engineer to obtain weir measurements of the canals, these were opposed and the weirs destroyed. The conditions, however, have become so onerous that a private corporation has taken upon itself the measurement of the river, systematic observations being begun in May, 1899.

The plant of the Salt Lake City Water and Electrical Power Company was completed in 1899, and is developing electric power which is used in the mining camps of Bingham and Mercur, Utah. The plant is located on Jordan River, about 20 miles south of Salt Lake City and 9 miles below the outlet of Utah Lake. This water-power company has been keeping a record of the discharge of Jordan River and of the various canals diverting water immediately above, but on account of pending lawsuits the data are not at present available. The water necessary to develop the power of this plant is diverted from Utah and Salt Lake canal, which heads about 2 miles above the plant, at what is known as the Point of the Mountain. It is taken from the west side of the river, at the same diversion point where the East Jordan canal diverts water to the east side. When the power house is reached an elevation of about 73 feet above the river has been attained by both canals, and this is the fall that is at present utilized. Halfway between the above-described dam and the power house there is a second dam across the river, from which two canals divert water—the City canal on the east side and the South Jordan canal on the west side. At the power plant, 1 mile below, these two canals have attained elevations of about 20 feet above the river. On December 6, 1899, measurements of the discharge of these canals, as well as of Jordan River, were made by Cyrus C. Babb at the gaging stations of the Salt Lake City Water and Electrical Power Company. Utah and Salt Lake canal below the power company's diversion, at a gage height of 2.40 feet was discharging 27 second-feet; Utah and Salt Lake canal, above the power company's diversion, at a gage height of 4.13 feet, was di-

arging 80 second-feet; the South Jordan canal, at a gage height of 33 feet, was discharging 19 second-feet; Jordan canal, at a gage eight of 4.15 feet, was carrying 111 second-feet; City canal, at a gage eight of 3.20 feet, was discharging 45 second-feet; East Jordan canal, ith a gage height of 1.02 feet, was discharging 6 second-feet. A easurement was also made of the tailrace of the power plant, in order compare it with the difference in the two measurements of Utah and alt Lake canal, and a discharge of 56 second-feet was found.

The city engineer of Salt Lake City, Mr. Frank C. Kelsey, has been eeping a record of the discharge of various small streams in the icinity of Salt Lake City, in connection with the city water supply. he following are the creeks, with the drainage areas in their respective anyons: Little Cottonwood Creek, 27.72 square miles; Big Cottonood Creek, 48.47 square miles; Mill Creek, 21.29 square miles; Parys Creek, 50.14 square miles; Emigration Creek, 18.92 square miles; ed Butte Creek, 11.59 square miles; City Creek, 19.15 square miles.

On Little Cottonwood Creek measurements are taken twice a day f the height of water passing over a Cippoletti weir 18 feet long. he record is from November 11, 1898, to May 20, 1899. At this latter ate the weir was washed out by a flood and funds could not be proured to replace it.

The station on Big Cottonwood Creek is placed below the Utah ower Company's building. A record was commenced on October 1, 1898, the measurements being taken over a rectangular weir 16 eet long.

The measurements on Mill Creek were started September 8, 1898, nd are made over a Cippoletti weir placed in the canyon. April 10, 899, this weir was removed by the water master of the district, but as replaced on the 30th of the same month.

There is an interesting double Cippoletti weir on Parleys Creek, hich is so controlled that the entire weir can be lifted, allowing the ravel and deposit from above to be washed out from time to time. he records from this point are fragmentary and were not obtained y this office.

aily mean discharge, in second-feet, of Little Cottonwood Creek near Salt Lake City, Utah, for 1898.

[Drainage area, 27.72 square miles.]

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1	.....	14	8	.....	12	14	13	14	20	12	12	26	10	12
2	.....	13	9	.....	11	15	13	12	21	10	11	27	13	12
3	.....	10	10	.....	12	16	11	11	22	11	10	28	14	13
4	.....	10	11	12	13	17	11	12	23	14	11	29	15	12
5	.....	13	12	12	13	18	11	12	24	14	13	30	14	11
6	.....	11	13	13	13	19	11	12	25	9	12	31	.....	12
7	.....	11												

Daily mean discharge, in second-feet, of Little Cottonwood Creek near Salt Lake City, Utah, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	Day.	Jan.	Feb.	Mar.	Apr.	May.
1	12	12	13	13	52	17	10	12	13	50	12
2	12	12	12	14	48	18	12	12	13	53	12
3	12	11	11	13	46	19	13	12	13	50	12
4	12	10	10	14	44	20	13	12	13	46	12
5	13	9	10	14	44	21	12	12	13	48	.....
6	12	9	13	13	48	22	12	11	12	54	.....
7	13	11	12	14	47	23	11	12	13	54	.....
8	14	12	12	15	53	24	12	12	13	64	.....
9	12	9	13	18	65	25	12	12	14	64	.....
10	12	9	12	23	72	26	12	12	14	63	.....
11	12	11	12	30	92	27	12	12	13	61	.....
12	12	11	12	34	119	28	12	12	13	55	.....
13	12	13	12	41	146	29	12	.....	13	52	.....
14	12	12	12	41	149	30	12	.....	13	51	.....
15	12	12	12	46	135	31	12	.....	13	.....	.....
16	11	12	12	51	120						

May 21 weir washed out and not replaced.

Daily mean discharge, in second-feet, of Big Cottonwood Creek near Salt Lake City, Utah, for 1898.

[Drainage area, 48.47 square miles.]

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	.....	34	36	12	.....	31	26	22	.....	35	19
2	.....	34	36	13	.....	33	30	23	.....	33	19
3	.....	36	30	14	.....	32	30	24	.....	35	16
4	.....	36	30	15	.....	32	21	25	.....	31	19
5	.....	35	33	16	.....	33	21	26	.....	31	18
6	.....	35	32	17	.....	31	22	27	.....	31	21
7	.....	34	31	18	.....	34	21	28	.....	33	.....
8	.....	35	29	19	.....	33	20	29	.....	37	.....
9	.....	27	31	20	.....	30	21	30	34	36	.....
10	.....	30	29	21	.....	32	19	31	33	.....	.....
11	.....	32	26								

Daily mean discharge, in second-feet, of Big Cottonwood Creek near Salt Lake City, Utah, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1	.....	25	26	36	78	211	240	71
2	.....	26	28	36	74	220	218	68
3	.....	21	26	35	68	237	204	70
4	.....	18	27	35	67	320	203	73
5	.....	12	25	42	68	335	206	73
6	.....	12	28	43	77	326	202	72
7	.....	13	29	47	93	326	182	73
8	.....	19	32	53	108	335	174	65
9	.....	9	37	68	141	377	170	65
10	.....	34	30	83	154	407	168	61
11	.....	29	31	114	180	560	157	61
12	.....	27	29	102	231	632	165	58
13	.....	26	30	135	263	593	154	57
14	.....	28	29	127	260	481	147	56
15	22	27	31	130	236	472	134	56
16	21	27	30	140	217	479	137	52
17	26	29	31	134	212	494	128	.....
18	25	28	32	130	214	523	121	.....
19	25	27	30	105	215	561	117	.....
20	24	27	31	92	216	587	115	.....
21	25	28	29	87	188	387	112	.....
22	26	26	31	112	173	301	105	.....
23	24	27	32	130	183	276	86	.....
24	25	27	39	150	228	267	94	.....
25	25	26	43	147	258	273	90	.....
26	25	25	44	135	254	254	88	.....
27	25	26	40	121	266	244	85	.....
28	29	26	37	103	240	244	84	.....
29	25	.....	35	89	225	246	80	.....
30	26	.....	35	83	211	246	82	.....
31	26	.....	36	.....	198	.....	76	.....

ily mean discharge, in second-feet, of Mill Creek near Salt Lake City, Utah, for 1898.

[Drainage area, 21.29 square miles.]

ay.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1	.....	14	8	.....	8	14	14	10	20	11	13	26	10	12
2	.....	13	9	.....	3	15	12	13	21	10	14	27	13	13
3	.....	9	10	.....	3	16	13	13	22	14	13	28	14	13
4	.....	9	11	14	3	17	13	13	23	14	12	29	14	12
5	.....	13	12	13	3	18	13	13	24	12	13	30	14	11
6	.....	10	13	14	3	19	12	13	25	11	13	31	.....	12
7	.....	6												

ily mean discharge, in second-feet, of Mill Creek near Salt Lake City, Utah, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	12	12	12	12	24	35	36	20	17	12	14
2	12	12	12	13	26	38	34	20	17	12	14
3	13	12	12	13	25	41	32	20	17	12	14
4	12	5	12	13	24	46	32	20	17	12	14
5	12	3	12	14	23	60	32	19	17	12	14
6	12	3	12	15	25	51	30	19	17	12	14
7	12	3	12	15	27	46	30	19	17	12	14
8	12	7	12	22	31	53	27	19	17	14	14
9	12	8	13	22	36	55	27	19	17	14	14
10	12	12	12	.....	31	55	27	18	17	14	14
11	12	12	12	.....	39	57	27	18	17	14	14
12	12	12	12	.....	43	60	25	18	15	14	13
13	12	12	12	.....	47	66	25	18	15	14	13
14	12	12	12	.....	47	66	25	18	15	14	13
15	12	12	12	.....	42	62	25	18	15	14	13
16	12	12	12	.....	40	59	25	18	15	14	.....
17	12	12	12	.....	38	66	25	18	15	14	.....
18	12	12	12	.....	40	60	25	18	15	14	.....
19	12	12	12	.....	40	56	25	18	15	14	.....
20	12	12	12	.....	35	56	25	18	15	14	.....
21	12	12	12	.....	32	56	25	18	15	14	.....
22	12	12	12	.....	33	48	22	18	15	14	.....
23	8	12	12	.....	35	46	22	18	15	14	.....
24	12	12	12	.....	37	45	22	17	15	14	.....
25	12	12	14	.....	37	41	22	17	15	14	.....
26	12	12	15	.....	41	40	22	17	15	14	.....
27	12	12	14	.....	42	38	21	17	15	14	.....
28	12	12	13	.....	40	37	21	17	15	18	.....
29	12	.....	13	.....	42	40	21	17	15	18	.....
30	12	.....	12	25	36	40	20	17	15	18	.....
31	12	.....	13	.....	34	.....	20	17	.....	18	.....

April 10 weir removed by water master; replaced April 30.

GREAT SALT LAKE.

Streams that contribute water to this lake have their sources in the asatch Mountains. The lake is very shallow, not averaging 20 et, while the deepest point is only 60 feet. The western and east-n shores slope very gradually, and the fall of a foot will expose many uare miles, while a rise of 6 feet would cover nearly one-tenth more a. At ordinary stages the area of the lake itself is about 2,280 square les. A record of the fluctuations of the surface has been maintained ce 1875, and they are published below, referred to Garfield Beach ge. The table published in the Thirteenth Annual Report, Part III, ge 20, refers to the shore gage, which datum is 4.6 feet above Gar-ld Beach gage. A further description of the fluctuations of this e will be found in Monograph I of the United States Geological rvey, entitled *Lake Bonneville*, by G. K. Gilbert, pages 233 to 238.

Gage heights of Great Salt Lake, referred to Garfield Beach gage.

Date.	Gage height.
1875.	*Feet.*
September 14	10.4
September 22	10.3
September 25	10.3
October 6	10.2
October 12	10.2
October 18	10.2
October 26	10.1
November 9	10.0
November 16	10.0
November 23	10.2
November 29	10.3
December 7	10.3
December 14	10.3
December 21	10.4
1876.	
January 5	10.5
January 11	10.6
January 29	10.6
February 1	10.6
February 15	10.7
February 22	10.7
March 15	10.8
March 22	10.9
March 28	10.9
April 17	11.0
April 25	11.1
May 2	11.2
May 22	11.6
June 2	11.8
June 8	11.9
June 13	12.0
June 23	12.2
June 30	12.4
July 18	12.1
July 25	12.2
August 1	12.1
August 10	12.0
August 22	11.6
August 29	11.5
August 30	11.5
September 14	11.5
September 19	11.4
September 26	11.4
October 9	11.3
1877.	
July 12	12.9
October 19	11.7
November 24	10.4
1878.	
January 21	10.5
March 28	10.6
May —	10.8
June 30	10.9
July 18	10.7
November 1	9.4
December 11	9.3
1879.	
May 2	9.6
November 19	7.1
December 2	7.1
December 16	7.2
December 31	7.3
1880.	
January 14	7.4
January 29	7.2
February 23	7.2
March 10	7.4
March 30	7.4
April 15	7.5
April 28	7.6
May 12	7.7
May 26	7.9
June 10	7.9
June 28	8.0
1880—Continued.	*Feet.*
July 13	7.9
July 30	7.7
August 14	7.5
August 29	7.3
September 14	7.0
September 29	6.8
October 15	6.6
October 29	6.5
November 12	6.3
November 29	6.3
December 11	6.3
December 14	6.3
December 27	6.4
1881.	
January 14	6.4
January 28	6.8
February 14	7.1
February 28	7.1
March 14	7.2
April 1	7.2
April 16	7.3
May 1	7.6
May 16	7.9
June 1	8.0
June 16	8.0
July 1	7.8
July 16	7.8
July 23	7.7
August 2	7.5
August 19	7.3
September 8	7.0
September 16	7.9
October 2	6.7
October 16	6.7
November 2	6.6
November 16	6.6
December 1	6.6
December 15	6.7
1882.	
January 2	6.7
January 16	6.8
February 2	6.8
February 16	6.9
March 2	6.9
March 21	7.0
April 1	7.2
April 16	7.2
May 2	7.4
May 16	7.5
June 2	7.5
June 16	7.5
July 2	7.3
July 17	7.2
August 2	7.0
August 15	6.8
September 2	6.4
September 16	6.2
October 2	6.1
October 15	6.0
December 15	6.0
December 30	6.0
1883.	
January 15	6.0
January 30	6.0
February 15	6.1
February 30	6.1
March 15	6.1
April 2	6.3
September 3	6.5
September 16	6.1
October 3	5.6
October 15	5.4
November 1	5.2
November 15	5.0
December 2	5.0
December 15	5.0

ge heights of Great Salt Lake, referred to Garfield Beach gage—Continued.

Date.	Gage height.
1884.	*Feet.*
January 2	5.0
January 15	5.0
February 2	5.0
February 15	5.1
March 1	5.2
March 15	5.5
April 1	5.6
April 15	5.9
May 2	6.2
May 15	6.5
June 1	7.0
June 15	7.2
July 1	7.4
July 15	7.4
August 2	7.2
August 15	7.0
September 1	7.0
September 15	7.0
October 2	7.0
October 15	6.9
November 1	6.9
November 15	6.8
December 2	6.8
December 15	6.9
1885.	
January 2	7.1
January 15	7.2
February 2	7.3
February 16	7.4
March 2	7.5
March 16	7.7
April 3	7.8
April 16	7.9
May 2	8.1
May 15	8.2
June 1	8.5
June 16	8.7
July 2	8.8
July 15	8.8
August 2	8.6
August 15	8.6
September 2	8.2
September 15	8.0
October 2	8.0
October 15	7.9
November 1	7.9
November 15	7.7
December 2	7.7
December 15	7.9
1886.	
January 2	8.0
January 15	8.1
February 2	8.3
February 15	8.4
March 2	8.6
March 15	8.7
April 1	8.8
April 15	8.9
May 2	9.0
May 15	9.1
June 2	9.2
July 29	8.8
October 2	8.2
November 6	8.0
December 28	8.2
1887.	
February 5	8.1
March 5	8.3
March 19	8.4
April 2	8.4
April 16	8.5
May 7	8.4
May 22	8.7
May 30	8.7
June 10	8.7
June 22	8.6
July 4	8.5
1887—Continued.	*Feet.*
July 14	8.4
August 6	8.1
September 5	7.7
September 20	7.3
October 4	7.3
October 25	7.1
November 11	7.1
1888.	
January 1	7.1
January 10	7.2
February 1	7.2
February 24	7.3
March 3	7.3
March 23	7.5
April 6	7.6
May 8	7.4
May 30	7.5
June 22	7.3
July 3	7.1
July 23	6.8
August 1	6.7
August 16	7.5
September 1	6.3
September 15	6.1
October 1	5.9
November 1	5.4
November 10	5.6
December 10	5.6
1889.	
January 1	5.6
January 15	5.6
February 1	5.7
February 15	5.8
March 1	6.0
March 25	6.1
April 15	6.8
May 1	5.9
May 20	5.8
June 1	5.7
June 25	5.4
July 12	4.9
August 10	4.5
August 30	4.1
September 23	3.6
October 12	3.6
December 14	3.7
1890.	
January 4	3.8
February 1	4.2
February 15	4.3
March 6	4.5
March 28	4.8
April 15	4.8
May 6	5.3
June 14	5.6
June 27	5.6
July 17	5.4
August 2	5.2
August 12	4.9
September 11	4.6
October 13	4.2
November 5	4.2
December 12	4.2
1891.	
January 5	4.3
January 30	4.3
February 18	4.3
March 2	4.6
March 16	4.6
April 2	4.7
April 15	4.7
May 1	4.9
June 2	5.0
August 15	4.3
September 9	4.3
September 19	3.9

Gage heights of Great Salt Lake, referred to Garfield Beach gage—Continued.

Date.	Gage height.
1891—Continued.	*Feet.*
October 5	3.9
October 17	3.8
November 2	3.9
November 18	3.8
December 1	3.8
December 16	3.8
1892.	
January 1	3.8
1893.	
January 1	3.2
January 14	3.3
January 30	3.4
February 14	3.5
February 28	3.5
March 14	3.7
March 30	3.9
April 14	4.1
April 29	4.3
May 13	4.5
May 29	4.5
June 15	4.5
July 1	4.3
July 15	4.2
July 31	3.5
August 15	3.3
August 30	3.3
September 15	3.0
September 30	2.8
October 1	2.5
1894.	
January 3	3.0
January 30	3.2
February 14	3.1
February 28	3.1
March 14	3.3
March 31	3.6
April 14	3.8
April 30	4.0
May 31	4.5
August 16	3.8
October 1	3.4
November 1	3.1
1896.	
January 1	2.3
February 1	2.5
March 1	2.6
April 1	2.8
May 1	2.8
June 1	3.3
July 1	3.3
August 1	2.8
September 1	2.4
October 1	2.2
November 1	1.9
December 1	2.0
1897.	
January 1	2.3
January 15	2.4
February 1	2.5
February 15	2.6
March 1	2.8
March 15	2.9
April 1	3.1
1897—Continued.	*Feet.*
April 15	3.2
May 1	3.4
May 15	3.6
June 1	3.8
June 15	3.7
July 1	3.5
July 15	3.3
August 1	3.
August 15	2.7
September 1	2.7
September 15	2.3
October 1	2.2
October 15	2.2
November 1	2.
November 15	2.
December 1	2.1
December 15	2.2
1898.	
January 1	2.3
January 15	2.4
February 1	2.4
February 15	2.5
March 1	2.7
March 15	2.8
April 1	2.9
April 15	3.1
May 1	3.2
May 15	3.3
June 1	3.4
June 15	3.3
July 1	3.3
July 15	3.1
August 1	2.8
August 15	2.6
September 1	2.2
September 15	1.9
October 1	1.8
October 15	1.7
November 1	1.5
November 15	1.4
December 1	1.3
December 15	1.3
1899.	
January 1	1.4
January 15	1.5
February 1	1.7
February 15	1.8
March 1	2.0
March 15	2.1
April 1	2.3
April 15	2.3
May 1	2.4
May 15	2.6
June 1	2.7
June 15	2.8
July 1	2.7
July 15	2.6
August 1	2.3
August 15	2.1
September 1	2.0
September 15	1.8
October 1	1.7
October 15	1.6
November 1	1.7
November 15	1.6
December 1	1.4
December 15	1.4

SNAKE RIVER AT GROVANT, WYOMING.

This river rises on the southern slope of the Continental Divide, in e Yellowstone National Park, draining the country west and south-est of Yellowstone Lake. From Shoshone, Lewes, and Heart lakes, ar its head, the river flows in a southerly direction through a tim-ered and mountainous country, resulting in a long period of high ater. After continuing through this area for about 20 miles it broad-s into Jackson Lake, a deep body of water about 3 miles wide and miles long. Below the lake the river flows through Jackson Hole alley—about 40 miles long and 8 miles wide—and then enters a long nyon near the Idaho-Wyoming line. All of the large tributaries me from the east, receiving their waters from the Wind River Range. e west side of the valley is bounded by the high Teton Mountains, om which most of the drainage flows westward through Teton River to North Fork of Snake River.

This area has been mapped in part by T. M. Bannon, who states that out 8,000 acres can be irrigated in Jackson Hole Valley. To do this ill necessitate the construction of five or six canals, owing to the sition of the agricultural lands. The small area now irrigated is atered by ditches, usually constructed by individuals and at little cost yond the labor. Cultivation is confined to small gardens and forage ops, the latter for winter feed of the stock that range in the country uring the summer season. During the winter the snow is so deep at the cattle must be fed for from three to five months.

The river station at Grovant was established April 2, 1899, by T. M. annon, at Menors Ferry, the location being shown on the Grand eton atlas sheet. A bench mark is located near Mr. Menor's house, est of the gage rod. The elevation of the bench mark is 6,457.864 et above sea level. The 5-foot mark on the gage rod is at an eleva-on of 6,448.483 feet. The channel above and below the ferry is raight and the bank sufficiently high to confine flood waters, this eing about the only place of this kind in the valley. The bed of the ream is of gravel. The place is most readily reached by hired con-eyance from St. Anthony, Idaho. The road crosses the North Fork f Snake River and the Teton River at the lower end of Teton Basin. leasurements can readily be made at these localities, particularly at e latter, where there is a stage station.

No measurements of discharge were made at this point during 1899.

Daily gage height, in feet, of Snake River at Grovant, Wyoming, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	0.44	2.75	6.66	2.75	0.75	0.25
2	0.02	.40	2.83	6.58	2.50	.75	.25
3	.04	.33	3.00	6.42	2.50	.75	.25
4	.08	.35	3.42	6.25	2.42	.75	.25
5	.10	.42	3.58	6.17	2.33	.75	.17
6	.10	.44	3.42	6.00	2.25	.67	.17
7	.10	.50	3.33	5.92	2.17	.67	.17
8	.13	.60	3.33	5.83	2.08	.67	.17
9	.15	.83	3.50	5.75	2.17	.67	.17
10	.13	.92	3.75	5.58	2.08	.67	.17
11	.13	1.17	4.08	5.50	2.00	.58	.17
12	.17	1.08	4.50	5.33	1.92	.58	.13
13	.25	1.17	4.50	5.50	1.83	.58	.13
14	.25	1.25	4.25	5.42	1.75	.58	.13
15	.25	1.33	4.33	5.17	1.67	.58	.17
16	.25	1.42	4.67	4.83	1.58	.50	.17
17	.23	1.42	5.08	4.67	1.50	.50	.21
18	.21	1.50	5.75	4.50	1.42	.50	.21
19	.21	1.67	6.25	4.33	1.33	.50	.25
20	.19	1.83	6.75	4.25	1.33	.42	.25
21	.23	1.83	6.83	4.17	1.25	.42	.29
22	.21	1.83	6.50	4.17	1.25	.42	.....
23	.23	1.75	6.25	4.00	1.17	.42	.....
24	.38	1.83	6.25	3.67	1.17	.42	.....
25	.52	2.08	6.13	3.42	1.08	.42	.....
26	.58	2.33	6.34	3.25	1.00	.42	.....
27	.54	2.42	6.41	3.17	.92	.33	.....
28	.46	2.50	6.41	3.17	.92	.33	.....
29	.44	2.67	6.63	3.00	.83	.33	.....
30	.42	2.83	6.75	3.00	.83	.33	.....
31	.....	2.75	.....	2.92	.75	.....	.....

Closed for winter October 21.

PORTNEUF RIVER AT POCATELLO, IDAHO.

This river is a tributary of Snake River, and rises in southeastern Idaho, its headwater tributaries draining the area immediately west of those of Blackfoot River. Its basin is almost wholly included within the Fort Hall Indian Reservation. There is little agricultural country along its course until Pocatello is reached, where the valley broadens to a considerable extent. This river will probably not be developed for irrigation purposes by private capital until the reservation is thrown open for settlement. The gaging station at Pocatello was established May 8, 1897, and is located at the wagon bridge one-eighth of a mile below the plant of the Pocatello Electric Power Company. The rod is vertical and is securely spiked to the west abutment of the bridge. The bench mark is a spike driven into the end of a log on the east abutment of the bridge, and is opposite the 13-foot mark. The channel above the station is curved, while below it is straight. The right bank is high, but the left is liable to overflow at a 12-foot gage height. The bed of the stream is rocky. The results of measurements may be found as follows: 1897–98, Twentieth Annual Report, Part IV, page 474. The following discharge measurements were made by F. S. Shirley and N. S. Dils during 1899:

March 30, gage height, 8 feet; discharge, 368 second-feet.
May 22, gage height, 9.10 feet; discharge, 614 second-feet.
June 25, gage height, 8.90 feet; discharge, 558 second-feet.
July 28, gage height, 7 feet; discharge, 123 second-feet.
August 27, gage height, 7.05 feet; discharge, 129 second-feet.

Daily gage height, in feet, of Portneuf River at Pocatello, Idaho, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	7.60	7.40	7.30	7.75	8.55	9.50	8.00	(a)	6.80	7.00
2	7.60	7.30	7.30	7.80	8.55	9.50	8.00	(a)	6.70	7.00
3	7.60	7.30	7.30	7.80	8.50	9.55	8.10	(a)	6.70	7.00
4	7.50	7.30	7.30	7.80	8.50	9.55	8.00	(a)	6.90	7.00
5	7.50	7.30	7.30	7.95	8.55	9.60	8.00	(a)	7.00	7.00
6	7.50	7.30	7.30	8.00	8.45	9.65	7.90	(a)	7.15	7.00
7	7.50	7.30	7.40	8.00	8.55	9.60	8.00	(a)	7.20	7.00
8	7.50	7.40	7.40	8.15	8.70	9.55	8.00	(a)	7.25	7.20
9	7.50	7.50	7.50	8.35	8.85	9.40	8.00	(a)	7.20	7.20
10	7.50	7.60	7.50	8.50	9.15	9.40	8.00	(a)	7.20	7.20
11	7.50	7.60	7.50	8.50	9.40	9.45	8.10	(a)	7.10	7.20
12	7.50	7.50	7.50	8.60	9.80	9.30	8.10	(a)	7.00	7.20
13	7.50	7.40	7.50	8.60	9.75	9.40	8.10	(a)	7.00	7.20
14	7.50	7.30	7.50	8.70	9.50	9.35	7.80	(a)	7.00	7.20
15	7.50	7.40	7.50	8.55	9.70	9.15	6.70	(a)	7.20	.....
16	7.60	7.50	7.50	8.55	(a)	9.05	7.80	(a)	7.00	.....
17	7.60	7.60	7.50	8.60	(a)	9.10	8.00	(a)	7.00	.....
18	7.50	7.70	7.50	8.55	(a)	9.00	8.00	(a)	7.00	.....
19	7.40	7.70	7.50	8.55	(a)	9.15	7.20	(a)	6.90	.....
20	7.40	7.60	7.50	8.40	(a)	9.25	7.00	(a)	6.90	.....
21	7.40	7.50	7.50	8.25	(a)	9.28	7.20	(a)	6.90	.....
22	7.60	7.40	7.50	8.40	9.20	9.00	7.40	(a)	6.90	.....
23	7.70	7.30	7.50	8.50	8.90	9.00	7.30	(a)	6.90	.....
24	7.60	7.40	7.50	8.60	9.00	8.95	6.80	(a)	7.00	.....
25	7.60	7.30	7.50	8.75	9.05	8.50	7.10	(a)	7.00	.....
26	7.60	7.30	7.80	8.80	9.00	8.40	7.20	(a)	7.00	.....
27	7.50	7.30	7.40	8.80	9.10	8.60	7.20	6.80	7.00	.....
28	7.50	7.30	8.20	8.75	9.20	8.70	7.10	6.90	7.00	.....
29	7.50	.....	7.90	8.55	9.25	8.60	7.20	6.85	7.00	.....
30	7.50	.....	7.80	8.65	9.45	8.10	7.20	6.90	7.00	.....
31	7.40	.....	7.80	.....	9.45	.....	.....	6.80	.....	.....

a No reading. Station discontinued October 14.

SNAKE RIVER AT MONTGOMERY FERRY, IDAHO.

This river passes from Wyoming into Idaho through a long and ccessible canyon in the Snake River Range. Its north fork has its arce in Henry Lake, in the Rocky Mountain divide, in the northstern corner of Idaho, and flows southerly, entering the main stream ar Idaho Falls. In the vicinity of Market Lake and Idaho Falls ere is a large area of land under cultivation, irrigated from canals ading on Snake River and its smaller tributaries. Ten miles above e gaging station at Montgomery Ferry occurs a natural dam site, om which, as a starting point, surveys for canal lines have been run, vering the large extent of rolling country susceptible of irrigation both sides of the river. This is a feasible project which up to the esent time has not been utilized. Measurements at Montgomery erry show the amount of water available for irrigation purposes there, d also the amount that could be developed for power purposes at oshone Falls, about 45 miles below. The station, established August 1895, is located at Montgomery Ferry, on the stage road from Minika to Albion. The gage is inclined and fastened to posts set in the ound. The bench mark is the head of a spike in the east post of e tool house, 1.2 feet above the ground and 52 feet west of the gage. elevation is 17.50 feet above gage datum. The letters "B. M." are rked in black paint on the post. The river is 800 feet wide at this ction, with a hard gravel bottom not subject to change. When the

station was visited by N. S. Dils on October 14, 1899, a comparison was made of the gage rod with the bench mark, and it was found that the rod had moved to a considerable extent, due to the action of the quicksand on the inclined portion of the rod. The heights as recorded by the observer, as well as the discharge measurements, have been corrected. The rod is inclined from zero to 6.5 feet, and is vertical above this latter elevation. The lower portion is fastened at various intervals to posts driven into the ground. Owing to its considerable length the rod has not moved uniformly, and the corrections, therefore, are not in a constant ratio. From zero to 2.5 feet the correction to the gage heights is below one-tenth of a foot; from 2.6 to 3.7 feet, one-tenth of a foot should be added to the gage heights; from 3.8 to 4.9 feet, as the correction is below one-tenth of a foot it is negligible; from 5.0 feet to 6.5 feet the correction varies from 0.2 foot to 0.4 foot. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 335; 1897, Nineteenth Annual Report, Part IV, page 447; 1898, Twentieth Annual Report, Part IV, page 474. The following measurements of discharge were made by F. S. Shirley and N. S. Dils during 1899:

March 29, gage height, 3.04 feet; discharge, 5,688 second-feet.
May 23, gage height, 6.40 feet; discharge, 16,587 second-feet.
June 27, gage height, 10.70 feet; discharge, 35,718 second-feet.
July 29, gage height, 6.10 feet; discharge, 15,012 second-feet.
August 28, gage height, 3.68 feet; discharge, 7,292 second-feet.
October 14, gage height, 3.15 feet; discharge, 5,911 second-feet.

Daily gage height, in feet, of Snake River at Montgomery Ferry, Idaho, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	3.40	2.85	2.95	2.90	4.30	7.35	10.50	5.65	3.60	3.05
2	3.45	2.80	3.00	2.95	4.10	7.40	10.70	5.50	3.55	3.05
3	3.50	2.85	2.90	2.95	4.05	7.40	10.80	5.30	3.50	3.06
4	3.35	3.80	2.80	2.85	4.05	7.55	10.60	5.00	3.40	3.05
5	3.35	3.95	2.75	2.90	3.90	7.75	10.50	4.85	3.40	3.05
6	3.35	3.85	2.55	2.85	3.80	8.05	10.45	4.85	3.40	3.05
7	3.40	3.70	2.75	2.80	3.70	8.45	10.25	4.75	3.30	3.05
8	3.40	3.55	2.75	2.80	3.70	8.65	10.00	4.75	3.30	3.10
9	3.40	3.35	2.70	2.75	3.80	8.35	9.85	4.65	3.30	3.10
10	3.40	3.15	2.90	2.75	4.10	8.05	9.55	4.55	3.25	3.10
11	3.30	3.00	2.85	2.80	4.45	7.75	9.30	4.55	3.20	3.15
12	3.30	2.90	2.85	2.80	5.40	7.95	9.05	4.45	3.20	3.15
13	3.45	3.05	2.80	2.85	6.05	8.30	8.85	4.45	3.20	3.15
14	3.55	3.20	2.85	3.00	6.40	8.80	8.65	4.35	3.20	3.15
15	3.65	3.45	2.85	3.00	6.80	9.10	8.60	4.25	3.10	3.15
16	3.75	3.80	2.80	3.10	6.65	9.15	8.55	4.15	3.10	.....
17	3.90	3.75	2.85	3.35	6.60	8.80	8.45	4.15	3.10	.....
18	4.15	3.85	2.90	3.25	6.65	8.65	8.30	4.05	3.10	.....
19	4.25	2.95	2.90	3.55	6.50	8.85	8.10	3.95	3.00	.....
20	4.25	2.55	2.90	3.50	6.20	9.35	7.70	3.95	3.05	.....
21	4.50	2.75	2.90	3.50	6.20	9.95	7.45	3.85	3.10	.....
22	4.50	2.85	2.90	3.40	6.35	10.35	7.25	3.80	3.10	.....
23	4.50	2.80	2.85	3.30	6.40	10.75	7.05	3.80	3.10	.....
24	4.35	2.70	2.90	3.20	6.25	11.05	6.80	3.80	3.10	.....
25	4.35	2.70	2.90	3.30	6.10	11.20	6.75	3.80	3.10	.....
26	3.85	2.70	3.00	3.65	6.10	10.90	6.65	3.80	3.10	.....
27	3.20	2.45	3.00	3.95	6.45	10.55	6.50	3.80	3.10	.....
28	2.95	2.85	3.00	4.30	6.65	10.40	6.35	3.68	3.08	.....
29	2.75	.....	3.00	4.65	7.10	10.40	6.15	3.65	3.05	.....
30	2.70	.....	3.00	4.50	7.20	10.40	5.90	3.60	3.05	.....
31	3.00	.....	3.00	.....	7.25	.....	5.80	3.60	.....	.....

Station discontinued October 15.

LITTLE WOOD RIVER AT TOPONIS, IDAHO.

headwater tributaries of this river drain a country adjoining of Malade River on the east. It enters Snake River Desert and a area on its appearance from its mountainous basin. Irrigation ticed along its course to such an extent that on the lower reaches er is dry during the summer period. A measurement on this t Shoshone, made by N. S. Dils on August 29, 1899, showed a rge of 71 second-feet. At this time the gage at Toponis showed harge of 9 second-feet. The station was established June 2, nd is located at the highway bridge one-half mile south of the d. The rod of the old wire gage was fastened to the floor of the , but it was replaced March 28, 1899, by a vertical rod which is to one of the supports of the bridge. The bench mark is a spike te the 8-foot mark on the bridge support to which the rod is ed. During the flood periods two side channels have to be red, as well as the main stream. The results of measurements e found as follows: 1896, Eighteenth Annual Report, Part IV, 37; 1897, Nineteenth Annual Report, Part IV, page 449. The ing discharge measurements were made by F. S. Shirley and Dils during 1899:

March 28, gage height, 4.40 feet; discharge, 164 second-feet.
March 28, gage height;[1] discharge, 25 second-feet.
May 25, gage height, 1.50 feet; discharge, 0.1 second-feet.
June 24, gage height, 2 feet; discharge, 11 second-feet.

Daily gage height, in feet, of Little Wood River at Toponis, Idaho, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
.....	4.50	4.25	3.05	1.00	1.60	1.30	1.80	2.50
.....	5.60	4.25	3.15	.90	1.70	1.20	1.80	2.60
.....	5.60	4.20	3.05	.90	1.70	1.10	1.80	2.60
.....	5.40	4.40	3.05	1.00	1.70	1.00	2.25	2.70
.....	5.30	4.40	2.90	1.20	1.75	1.00	2.25	2.90
.....	5.20	4.50	2.85	1.75	1.70	1.70	2.00	2.90
.....	5.00	4.40	2.65	1.60	1.70	1.50	1.80	2.90
.....	5.00	4.30	2.65	1.70	1.60	1.50	1.70	2.90
.....	4.80	4.40	2.60	1.70	1.70	1.30	1.70	3.00
.....	4.85	4.25	2.60	1.65	1.70	1.50	1.70	3.00
.....	4.80	4.10	2.50	1.70	1.85	1.70	1.60	3.00
.....	5.00	4.10	2.40	1.70	1.80	1.75	1.60	3.00
.....	4.60	4.00	2.25	1.60	1.80	1.75	1.60	3.10
.....	4.50	3.90	2.05	1.60	1.75	1.75	1.70	3.10
.....	4.50	3.80	2.00	1.50	1.70	1.75	1.70	.....
.....	4.30	3.80	1.80	1.45	1.70	1.75	1.70	.....
.....	4.00	3.75	1.70	1.35	1.70	1.75	1.50	.....
.....	3.90	3.70	1.30	1.30	1.75	1.75	1.50	.....
.....	4.00	3.70	1.50	1.25	1.75	1.80	1.60	.....
.....	3.80	3.70	1.50	1.10	1.70	1.80	1.70	.....
.....	3.80	3.70	1.50	1.00	1.70	1.75	1.70	.....
.....	3.85	3.50	1.50	1.90	1.55	1.75	1.60	.....
.....	3.85	3.50	1.50	2.00	1.60	1.90	1.60	.....
.....	3.90	3.50	1.50	1.95	1.70	2.10	2.10	.....
.....	4.00	3.30	1.50	1.65	1.60	2.00	2.30	.....
.....	4.20	3.20	1.50	1.65	1.70	1.80	2.40	.....
.....	4.35	3.25	1.50	1.70	1.70	1.80	2.50	.....
.....	4.45	3.25	1.40	1.70	1.70	1.80	2.50	.....
.....	4.20	3.20	1.40	1.65	1.75	1.80	2.50	.....
.....	4.10	2.95	1.20	1.60	1.70	1.80	2.50	.....
.....	4.10	.....	1.00	.....	1.50	1.80	.....	.....

Station discontinued October 14.

urement made on a slough, 500 feet south of railroad, into which water had been diverted tle Wood River for irrigation purposes.

MALADE RIVER AT TOPONIS, IDAHO.

Malade River, or Big Wood, as it is sometimes called, has its source in the high, mountainous area north of Ketchum, Idaho, and flows southerly. Below the mouth of its tributary, Camas Creek, which enters from the west, the main stream enters a broken lava country in which there is no surface addition to its flow, the rainfall percolating down through the soil of the lava beds. Considerable irrigation is practiced within its basin, and a number of canal diversions are made above the station. Recourse must be had to storage on this river for further increase of its agricultural lands. The station, established June 2, 1896, is located at the wagon bridge one-half mile north of the town of Toponis. The gage is vertical and is spiked to the south face of one of the bridge piers. The bench mark is the head of a spike driven into the pier opposite the 12-foot mark. The channel is straight for some distance above and below the station, and the current is moderately swift. The banks are high and not liable to overflow. The results of measurements are found as follows: 1896, Eighteenth Annual Report, Part IV, page 337; 1897, Nineteenth Annual Report, Part IV, page 449; 1898, Twentieth Annual Report, Part IV, page 477. The following measurements of discharge were made by F. S. Shirley and N. S. Dils during 1899:

March 28, gage height, 2.40 feet; discharge, 42 second-feet.
May 25, gage height, 3.80 feet; discharge, 523 second-feet.
June 24, gage height, 5 feet; discharge, 1,356 second-feet.
July 27, gage height, 2.80 feet; discharge, 125 second-feet.

Daily gage height, in feet, of Malade River at Toponis, Idaho, for 1899.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	2.00	2.60	3.80	4.20	4.60	2.50	1.20	2.00
2	.....	2.30	2.85	3.80	4.25	4.60	2.40	1.20	1.95
3	.....	2.45	2.75	3.30	4.25	4.60	2.30	1.20	1.95
4	.....	2.35	2.80	3.75	4.40	4.55	2.30	1.20	1.90
5	.....	2.20	2.70	3.80	4.55	4.50	2.20	1.20	1.90
6	.....	2.30	2.65	3.90	4.60	4.10	2.10	1.20	1.90
7	.....	2.45	2.75	3.90	4.60	3.90	2.00	1.90	1.85
8	.....	2.50	2.75	3.90	4.60	3.80	2.00	1.90	1.85
9	.....	2.55	2.90	3.70	4.40	3.70	2.00	1.90	1.90
10	.....	2.30	3.00	4.05	4.10	3.65	2.00	1.80	2.00
11	.....	2.05	3.00	4.30	4.20	3.65	1.90	1.70	2.00
12	.....	2.00	3.60	4.65	4.40	3.60	2.10	1.70	2.00
13	.....	2.00	4.10	5.00	4.40	3.55	2.10	1.70	2.00
14	.....	1.95	4.60	4.80	4.40	3.65	2.00	1.65	2.00
15	.....	1.70	4.75	4.60	4.40	3.60	2.00	1.60	.....
16	.....	1.60	5.10	4.70	4.40	3.45	2.00	1.60	.....
17	.....	2.60	5.55	4.50	4.50	3.30	2.00	1.60	.....
18	3.30	2.45	5.45	4.30	4.85	3.20	2.00	1.70	.....
19	2.90	2.45	6.20	4.20	4.70	3.10	1.90	1.80	.....
20	3.00	2.45	6.10	4.10	4.90	3.00	1.90	1.90	.....
21	2.60	2.45	5.10	4.00	5.20	3.00	1.80	1.80	.....
22	2.50	2.10	5.00	3.90	5.40	2.95	1.70	1.90	.....
23	2.40	2.40	5.00	3.90	5.05	2.90	1.50	1.90	.....
24	2.00	2.60	5.00	3.80	4.90	2.90	1.30	1.80	.....
25	2.10	3.70	5.00	3.80	4.90	2.80	1.30	1.90	.....
26	2.10	2.95	5.00	3.80	4.80	2.70	1.30	2.00	.....
27	2.05	2.50	5.40	4.00	4.75	2.70	1.55	2.00	.....
28	2.10	2.40	4.90	4.00	4.55	2.65	1.55	2.00	.....
29	.....	2.50	4.40	4.15	4.60	2.65	1.40	2.00	.....
30	.....	2.50	4.00	4.35	4.60	2.55	1.30	2.00	.....
31	.....	2.50	.....	4.30	.....	2.50	1.20	.....	.....

Closed for winter October 14.

MALADE RIVER AT BLISS, IDAHO.

ere is a large increase in the discharge of this river below the a of Little Wood River, which is evidently due to the entrance of gs from the lava desert. Surveys have recently been completed ler to determine the practicability of carrying water from lower le River across Snake River for placer mining and irrigation oses. In order to determine the increase by the underground and the amount available for future hydraulic developments, a on was established by Frank S. Shirley March 27, 1899. The on is located at the wagon bridge 8 miles southwest from the rail-station at Bliss, and is reached by stage from the latter place. rod is vertical and consists of a 2 by 4 inch timber spiked to the ge abutment. The bench mark is two nails driven into the east ment opposite the 12-foot mark. The locality is a good one for urements, with high banks not subject to overflow, and with a rocky not liable to change. The following measurements of discharge made by F. S. Shirley and N. S. Dils in 1899:

March 27, gage height, 2.50 feet; discharge, 1,345 second-feet.
May 26, gage height, 2.70 feet; discharge, 1,736 second-feet.
June 23, gage height, 3.50 feet; discharge, 2,878 second-feet.
July 26, gage height, 2.30 feet; discharge, 1,203 second-feet.
September 23, gage height, 2.15 feet; discharge, 1,095 second-feet.

Daily gage height, in feet, of Malade River at Bliss, Idaho, for 1899.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
.....	.....	2.40	2.90	2.90	3.00	2.20	2.15	2.20
.....	.....	2.70	2.80	2.90	3.00	2.20	2.15	2.20
.....	.....	2.70	2.80	2.90	3.00	2.20	2.15	2.20
.....	.....	2.60	2.70	2.90	3.00	2.20	2.15	2.20
.....	.....	2.50	2.70	2.90	3.00	2.20	2.15	2.20
.....	.....	2.60	2.60	3.00	2.90	2.15	2.15	2.20
.....	.....	2.50	2.50	3.00	2.80	2.15	2.15	2.20
.....	.....	2.50	2.50	3.00	2.70	2.15	2.15	2.20
.....	.....	2.90	2.50	2.90	2.70	2.15	2.15	2.20
.....	.....	2.90	2.70	2.90	2.70	2.15	2.15	2.20
.....	.....	2.90	2.90	2.90	2.70	2.15	2.15	2.20
.....	.....	3.00	3.10	3.00	2.60	2.15	2.15	2.20
.....	.....	3.00	3.50	3.00	2.60	2.15	2.15	2.20
.....	.....	3.10	3.30	3.10	2.60	2.15	2.15	2.20
.....	.....	3.30	3.30	3.00	2.60	2.15	2.15	.....
.....	.....	(a)	3.00	2.90	2.50	2.15	2.15	.....
.....	.....	3.50	3.00	2.90	2.50	2.15	2.15	.....
.....	.....	3.80	3.00	3.00	2.50	2.15	2.15	.....
.....	.....	3.90	2.90	3.30	2.40	2.15	2.15	.....
.....	.....	4.00	2.80	3.50	2.40	2.15	2.15	.....
.....	.....	3.50	(a)	3.80	2.30	2.15	2.15	.....
.....	.....	3.30	2.80	3.70	2.30	2.15	2.15	.....
.....	.....	(a)	2.70	3.50	2.30	2.15	2.15	.....
.....	.....	3.40	2.70	3.40	2.30	2.15	2.15	.....
.....	.....	3.60	2.60	3.30	2.30	2.15	2.15	.....
.....	.....	3.50	2.70	3.30	2.30	2.15	2.15	.....
.....	2.50	3.50	2.80	3.20	2.30	2.15	2.15	.....
.....	2.40	3.40	2.80	3.20	2.20	2.15	2.20	.....
.....	2.30	3.10	2.80	3.10	2.20	2.15	2.20	.....
.....	2.30	3.00	2.90	3.10	2.20	2.15	2.20	.....
.....	2.40	.....	2.90	.....	2.20	2.15	.....	.....

a No reading.

Closed for winter October 14.

BRUNEAU RIVER AT GRANDVIEW, IDAHO.

This river has its source in northern Nevada, and flows in a general northerly course, entering Snake River in Owyhee County. Its basin is of a rolling character and is devoted to stock raising. Systematic measurements on this river have been maintained by Mr. Andrew J. Wiley, for the Owyhee Land and Irrigation Company, immediately below the headworks of their canal system, 10 miles east of Grandview, Idaho. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 340; 1897, Nineteenth Annual Report, Part IV, page 450; 1898, Twentieth Annual Report, Part IV, page 482. No measurements were made at this station during 1899.

Daily gage height, in feet, of Bruneau River at Grandview, Idaho, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.50	1.80	1.70	2.40	3.20	3.95	3.75	1.90	1.45	1.45	1.70	1.70
2	1.50	1.80	1.70	2.50	3.10	4.00	3.70	1.85	1.40	1.50	1.70	1.70
3	1.50	1.70	1.90	2.50	3.00	4.25	3.60	1.80	1.45	1.50	1.70	1.65
4	1.50	1.60	1.90	2.50	2.90	4.65	3.50	1.80	1.40	1.50	1.70	1.65
5	1.50	1.30	1.70	2.50	2.80	4.65	3.45	1.75	1.40	1.50	1.70	1.65
6	1.55	1.25	1.75	2.60	2.80	7.85	3.30	1.85	1.40	1.50	1.75	1.60
7	1.55	1.20	1.75	2.70	2.95	4.95	3.25	1.90	1.40	1.50	1.75	1.60
8	1.55	1.20	1.70	2.80	3.30	4.80	3.20	1.80	1.40	1.55	1.75	1.65
9	1.60	1.50	2.30	3.10	3.50	4.75	3.15	1.80	1.40	1.55	1.70	1.65
10	1.60	1.65	2.50	3.40	4.00	4.70	3.00	1.85	1.40	1.55	1.70	1.65
11	1.60	2.50	2.30	4.50	4.65	4.75	3.00	1.80	1.45	1.50	1.75	1.65
12	1.55	2.30	2.00	4.50	4.85	4.90	2.90	1.80	1.45	1.55	1.75	1.65
13	1.55	1.90	1.90	5.00	5.00	5.15	2.80	1.75	1.40	1.55	1.75	1.70
14	1.55	1.80	1.90	5.20	5.00	5.15	2.80	1.75	1.45	1.60	1.70	1.70
15	1.60	1.80	1.80	5.00	4.80	4.80	2.75	1.70	1.45	1.65	1.80	1.65
16	3.90	1.80	1.80	4.80	4.55	4.60	2.70	1.65	1.45	1.65	1.75	1.65
17	2.55	1.80	1.85	5.00	4.40	4.65	2.60	1.60	1.40	1.70	1.70	1.70
18	2.30	1.75	1.85	5.00	4.00	4.75	2.55	1.65	1.40	1.70	1.70	1.70
19	2.30	1.70	2.00	4.40	3.80	5.00	2.50	1.65	1.45	1.70	1.70	1.65
20	2.00	1.75	1.95	4.20	3.70	5.00	2.45	1.65	1.45	1.70	1.70	1.60
21	1.85	2.30	1.90	3.90	3.55	5.20	2.40	1.60	1.45	1.75	1.70	1.55
22	1.90	2.40	1.90	4.00	3.45	5.00	2.35	1.65	1.45	1.75	1.70	1.55
23	1.80	2.00	1.90	4.40	3.40	4.60	2.25	1.60	1.45	1.70	1.70	1.50
24	1.80	1.80	1.85	4.40	3.50	4.30	2.20	1.65	1.45	1.70	1.70	1.50
25	1.75	1.80	3.00	4.30	3.70	4.20	2.20	1.60	1.45	1.70	1.70	1.50
26	1.80	1.75	4.40	4.30	3.95	4.25	2.10	1.60	1.45	1.75	1.70	1.50
27	1.80	1.70	3.40	3.80	4.00	4.10	2.05	1.60	1.50	1.75	1.70	1.55
28	1.80	1.70	3.00	3.70	3.85	4.00	2.00	1.55	1.50	1.75	1.70	1.50
29	1.80	.....	2.80	3.50	3.90	3.80	2.00	1.55	1.50	1.75	1.70	1.55
30	1.80	.....	2.60	3.30	3.85	3.75	1.95	1.50	1.50	1.70	1.70	1.60
31	1.80	.....	2.50	.....	4.15	.....	1.90	1.50	.....	1.70	.....	1.65

BOISE RIVER AT BOISE, IDAHO.

This river drains a mountainous and well-wooded country in Elmore County, Idaho. The effects of the forests are shown in the high flow that is maintained throughout the summer season, in contrast to the discharge of Weiser River farther to the west, which drains a more barren country. Below the gaging station, which is located in the canyon, a large number of canals divert water to irrigate lands in Boise Valley. These diversions are now carried to such an extent that frequent complaint of the scarcity of water is heard. It is estimated that 13,000 acres of land are irrigated by canals from Boise River. The station, established December 15, 1894, is located about 9 miles

above Boise, Idaho, at the mouth of the canyon. June 17, 1897, the present rod was placed, consisting of an inclined timber firmly attached to a cottonwood tree. Bench mark No. 1 is a 20-penny spike in the upstream face of the 6 by 8 cable support, about 2 feet above the ground, and is at an elevation of 15 feet above gage datum. Bench mark No. 2 consists of two spikes in the same post, at a height of 14 feet above gage datum. The equipment consists of a cable and car. At ordinary stages the channel is straight both above and below the station. The banks are high and not liable to overflow. About 300 feet below the cable is a gravel bar reducing the width of the river in low water to about one-third of the channel, and forcing the entire flow against the south bank. The channel is liable to change during extreme high floods. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 342; 1897, Nineteenth Annual Report, Part IV, page 453; 1898, Twentieth Annual Report, Part IV, page 483. The following discharge measurements were made by F. S. Shirley and N. S. Dils during 1899:

[illegible] Boise River at Boise, Idaho, 1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
March 24	1.90	1,846	July 21	4.30	7,394
April 4	2.70	5,418	August 2	2.00	2,054
May 16	5.10	9,927	August 3	1.55	1,563
May 28	8.10	20,721	September 14	1.20	1,105

Daily gage height, in feet, of Boise River at Boise, Idaho, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]		[illegible]		[illegible]		[illegible]	[illegible]		[illegible]		[illegible]

A series of measurements of Boise River and canals taking water from it were made by N. S. Dils September 12 to 16, 1899. The route followed was similar to that taken by Cyrus C. Babb, as noted in the Twentieth Annual, Part IV, page 484. The following list gives the localities, together with the results obtained:

Discharge measurements of canals in Boise Valley, Idaho.

1899.

Date.	Canal.	Locality.	Discharge.
			Second-feet.
Sept. 12	Sebree	Near head	198
Sept. 12	Seitenberg slough	Near head	47
Sept. 12	Boise River	300 feet below Caldwell bridge.	439
Sept. 12	Riverside canal	Near head	10
Sept. 12	Waste east of Caldwell	Near river	7
Sept. 12	Waste Tenmile	Near river	35
Sept. 12	Strahorn canal	Near head	49
Sept. 12	Four small wastes	Near river	2
Sept. 12	Boise River	Star bridge	486
Sept. 13	Waste south of Star	Near river	22
Sept. 13	Waste south of Star bridge	Near river	5
Sept. 13	Eureka canal	Near head	47
Sept. 13	Phyllis canal	Near head; dry	.....
Sept. 13	Settlers canal	Near head	52
Sept. 13	McCarty canal	Near head	11
Sept. 13	Davis canal	Near head	20
Sept. 13	Waste Rossi	Near river	43
Sept. 13	Payne canal	Near head	5
Sept. 13	Rossi canal	Below waste gate	51
Sept. 14	Perault canal	Below mill	25
Sept. 14	Ellis canal	Near head	3
Sept. 14	Perault canal [1]	Below waste gate	88
Sept. 14	Boise River	United States Geological Survey gaging station.	1,105
Sept. 14	Costin canal	Near head	3
Sept. 14	Ridenbaugh canal	Near head	356
Sept. 14	Jacobs canal	Near head	43
Sept. 15	Waste Carline	Main street bridge	20
Sept. 15	Farmers Union	Near head	47
Sept. 15	Waste	One-half mile below Soldiers' Home.	7
Sept. 15	Waste	Two miles below Soldiers' Home.	7
Sept. 15	Dry Creek canal	Near head	23
Sept. 15	Union canal	Near head; dry	.....
Sept. 15	Ballentine canal	Near head; dry	.....
Sept. 15	Waste Dry Creek	Near river	2
Sept. 15	Waste	Near head; Cassiday	3
Sept. 15	Cassiday canal	Near head; dry	.....
Sept. 15	Middleton canal	Near head	84
Sept. 15	Swallew & McDowell	Near head	8
Sept. 16	Catlin & Macey	Eagle Island	14
Sept. 16	Aitken	Eagle Island	7
Sept. 16	Conway & Aitken	Eagle Island	7
Sept. 16	Davis & Hart	Eagle Island	7
Sept. 16	Middleton Mill slough	Near head	14
Sept. 16	Pioneer canal	Near head	3
Sept. 16	Middleton Water Company	Near head	32
Sept. 16	Waste West Middleton	Willow Creek	13
Sept. 16	Waste West Middleton	Near river	1
Sept. 16	Waste East Middleton	Near river	17

[1] Perault above mill feeds Perault below mill and waste flows into Ellis canal.

SUMMARY.

	Second-feet.
n river at Star bridge	486
aken out by canals above Star	891
	1,377
n river above canals	1,105
eturn water above Star	91
	1,196
Gain	181
river at Caldwell	439
aken out by canals	1,227
	1,666
river above canals	1,105
eturn water	192
	1,297
Gain 34 miles	369
ain per mile, 1899	11
ain per mile, 1898	8
Increase	3

PAYETTE RIVER AT PAYETTE, IDAHO.

This river drains a well-wooded mountainous area similar to the sin of the Boise. The effect of the forest is shown in the well-stained summer flow. Systematic measurements were formerly ade on this river, but owing to the excess of water above the needs the irrigators, this station is not now maintained. September 10, 99, a measurement at Payette by N. S. Dils showed a discharge of 377 second-feet.

WEISER RIVER AT WEISER, IDAHO.

The drainage basin of this river is mountainous and rocky, in con-ast to the well-wooded areas of the Boise and Payette basins, and e effect is shown in the high flood discharges and low summer flow. number of small ditches utilize considerable water from this river, it the principal canal is the Galloway canal, which irrigates lands orth of Weiser. Above this canal is a bench country susceptible cultivation if water could be brought to it. The gaging station, tablished December 6, 1894, is located in the canyon of the river, out 10 miles from Weiser. The gage rod which was set in 1898 as covered during the process of grading for the roadbed of the w Pacific and Idaho Northern railroad, which is a line intended run from Weiser to the mining country in the mountainous district the north. The new gage, located on October 31, 1899, 100 feet

above the old one, is inclined and bolted to a rock bluff; 1.15 feet along the gage equals one foot in elevation. The bench mark consists of a cross cut in the top of the lava rim rock above the gage, and is at an elevation of 12.90 feet. The elevation of the zero of the gage taken from the levels of the railroad is 2,191.34 feet above sea level. Discharge measurements are made from a cable and car about 300 feet below the gage. Both banks are high and not liable to overflow. The bed of the river is of gravel and not susceptible to change. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 353; 1897, Nineteenth Annual Report, Part IV, page 457; 1898, Twentieth Annual Report, Part IV, page 488. The following discharge measurements were made by F. S. Shirley and N. S. Dils in 1899:

March 22, gage height, 3.80 feet; discharge, 2,822 second-feet.
April 16, gage height, 4.70 feet; discharge, 3,831 second-feet.
May 18, gage height, 4.20 feet; discharge, 3,092 second-feet.
May 29, gage height, 4 feet; discharge, 2,839 second-feet.
July 8, gage height, 2.40 feet; discharge, 1,195 second-feet.
September 9, gage height, 0.75 foot; discharge, 145 second-feet.

Daily gage height, in feet, of Weiser River at Weiser, Idaho, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.00	1.60	2.10	5.00	3.80	4.10	3.20	1.20	0.80	0.50	1.10	2.40
2	2.00	1.50	2.20	5.00	3.40	4.30	3.00	1.20	.80	.50	1.10	2.30
3	2.00	1.60	2.30	5.10	3.20	4.70	2.90	1.20	.80	.50	1.10	2.20
4	2.00	1.80	2.40	5.00	3.05	4.90	2.80	1.10	.80	.50	1.10	2.10
5	2.00	1.90	2.30	5.00	3.00	4.60	2.70	1.10	.80	.50	1.10	2.00
6	2.00	2.00	2.30	5.10	3.15	4.30	2.60	1.10	.80	.50	1.10	.....
7	2.00	1.80	2.40	5.00	3.70	4.00	2.50	1.10	.80	.50	1.10	.....
8	2.00	1.70	2.50	4.90	4.40	3.80	2.40	1.00	.80	.50	1.50	.....
9	2.00	1.60	2.60	5.05	4.90	3.80	2.30	1.00	.80	.50	1.60	.....
10	2.00	1.50	2.70	5.15	5.15	3.90	2.20	1.00	.80	.50	1.70	.....
11	2.00	1.40	2.80	5.10	5.30	4.00	2.20	1.00	.80	.60	1.90	.....
12	2.00	1.40	2.60	5.20	5.20	4.10	2.10	1.00	.70	.60	2.00	.....
13	2.00	1.40	2.60	5.60	5.20	4.20	2.10	.90	.70	.60	2.00	.....
14	2.00	1.40	2.70	5.30	4.70	4.20	2.00	.90	.70	.60	1.90	.....
15	2.00	1.40	2.80	4.70	4.40	4.30	2.00	.90	.70	.60	1.80	.....
16	2.10	1.40	3.00	4.70	4.00	4.30	2.90	.90	.70	.80	1.70	.....
17	2.20	1.40	4.70	4.90	3.80	4.30	2.90	.90	.70	.80	1.60	.....
18	2.40	1.45	4.80	4.60	3.70	4.40	2.80	.90	.70	.90	1.60	.....
19	2.60	1.50	4.60	4.30	3.60	4.60	1.80	.80	.70	1.00	1.60	.....
20	3.60	1.65	4.50	4.10	3.60	4.60	1.70	.80	.70	1.20	1.70	.....
21	3.90	1.70	4.20	4.00	3.60	4.50	1.70	.80	.60	1.30	1.70	.....
22	4.40	1.70	3.80	4.30	3.60	4.10	1.60	.80	.60	1.40	1.80	.....
23	5.00	1.70	3.70	4.20	3.70	3.80	1.60	.80	.60	1.40	1.80	.....
24	5.60	1.60	6.35	4.00	4.00	3.80	1.50	.80	.60	1.30	2.00	.....
25	5.00	1.60	6.40	4.60	4.30	3.70	1.50	.90	.60	1.30	2.30	.....
26	3.60	1.70	6.30	4.60	4.30	3.70	1.40	.90	.60	1.20	2.80	.....
27	3.00	1.80	6.80	4.00	4.20	3.60	1.40	.90	.50	1.20	3.00	.....
28	2.60	1.90	4.90	3.80	4.20	3.50	1.40	.80	.50	1.20	4.10	.....
29	2.20	.....	4.80	3.80	4.00	3.40	1.30	.80	.50	1.10	4.20	.....
30	2.20	.....	5.20	3.70	4.00	3.30	1.30	.80	.50	1.10	4.30	.....
31	1.70	.....	5.00	.....	4.05	.....	1.30	.80	.....	1.10	.....	.....

River frozen; closed for winter December 5.

PALOUSE RIVER AT HOOPER, WASHINGTON.

The headwater tributaries of this river have their sources in western Idaho, adjoining the headwater streams of Potlatch River, a tributary of Clearwater River. After passing into Washington they

e to form the main Palouse, which has a general southwesterly ction, passing through a rolling country. Six miles below Hooper, hington, the river bends suddenly southward and enters its canyon, ugh which it continues until its junction with Snake River. For e distance above Hooper the river consists of a succession of deep s, from 10 to 15 feet in depth, connected by short riffles. Its valley out one-half mile in width and bordered with basaltic cliffs approxely 300 feet in height. A short distance above the mouth of the r are the Palouse Falls, which are approximately 130 feet in height. ne measurements of Palouse River are of value in showing the unt of water that could be utilized for irrigation on the lands of ihtucna Valley and in the section north of Pasco. The gaging on, established September 9, 1897, is located near Hooper, opposite water tank of the railroad company. It is about 3 miles above the th of Cow Creek and 2 miles below the head of the ditch of Palouse Irrigation Company, which carries, when full, 25 second- . The rod is inclined and fastened to posts driven into the right k. The bench mark is a point of rock, marked with red paint, on left bank of the river, opposite the gage, and its elevation is 7.60 above gage datum. The channel is gravel and not liable to change. left bank is high and can not overflow, but the right bank rflows at extreme high water. The results of measurements may ound as follows: 1897, Nineteenth Annual Report, Part IV, page ; 1898, Twentieth Annual Report, Part IV, page 489. No measnents of discharge were made at this point in 1899.

Daily gage height, in feet, of Palouse River at Hooper, Washington, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.70	5.30	4.70	5.10	5.40	3.45	2.25	1.60	1.60	1.50	2.10	4.40
2	2.60	5.20	6.45	5.00	5.40	3.35	2.30	1.60	1.60	1.50	2.05	5.00
3	2.60	4.70	6.30	5.30	5.25	3.30	2.35	1.55	1.60	1.50	2.05	5.50
4	2.60	4.30	5.90	5.30	4.90	3.25	2.30	1.55	1.60	1.50	2.00	5.80
5	2.55	4.00	5.40	5.45	4.50	3.30	2.25	1.55	1.60	1.50	1.95	5.50
6	2.30	4.00	5.25	5.30	4.30	3.35	2.25	1.50	1.65	1.50	1.95	4.70
7	2.10	3.90	5.10	5.20	4.20	3.40	2.20	1.50	1.60	1.50	1.95	4.30
8	2.30	3.80	5.45	5.20	4.40	3.20	2.20	1.45	1.60	1.50	1.90	4.10
9	2.45	3.80	5.80	5.60	4.90	3.10	2.15	1.45	1.60	1.50	1.90	3.90
0	2.50	3.90	6.40	5.85	5.65	3.00	2.10	1.45	1.65	1.50	1.95	3.90
1	2.55	4.20	6.50	6.35	5.85	2.80	1.95	1.40	1.70	1.50	1.95	3.90
2	2.55	3.90	5.90	6.85	5.90	2.70	1.80	1.40	1.70	1.50	1.95	3.90
3	2.50	3.90	5.70	7.65	5.55	2.70	1.75	1.40	1.65	1.50	1.95	3.80
4	2.50	3.90	5.45	9.65	5.20	2.80	1.75	1.40	1.65	1.50	2.00	4.05
5	2.80	5.15	5.15	8.75	4.90	2.80	1.70	1.40	1.65	1.50	2.00	3.90
6	4.10	7.30	5.00	7.30	4.40	2.65	1.70	1.45	1.65	1.50	2.05	3.65
7	3.90	8.10	4.80	6.50	4.15	2.55	1.95	1.45	1.60	1.55	2.10	3.50
8	5.60	8.15	5.40	6.60	4.00	2.45	1.90	1.40	1.60	1.60	2.15	3.40
9	6.40	8.00	5.10	7.00	4.05	2.35	1.80	1.50	1.65	1.65	2.15	3.30
0	6.45	7.90	4.90	6.70	4.00	2.35	1.65	1.60	1.70	1.80	2.15	3.10
1	6.55	7.50	4.85	6.40	3.90	2.25	1.60	1.55	1.65	2.05	2.20	3.35
2	7.55	7.00	5.25	5.80	3.85	2.25	1.60	1.65	1.60	2.30	3.15	3.40
3	8.00	6.50	5.00	5.65	3.80	2.25	1.55	1.65	1.60	2.30	3.10	3.60
4	8.50	5.30	5.15	5.80	3.65	2.20	1.50	1.60	1.60	2.60	2.90	4.70
5	7.70	5.00	5.70	5.60	3.70	2.20	1.40	1.60	1.60	2.40	2.90	5.00
6	7.10	4.70	5.45	5.40	3.85	2.20	1.45	1.55	1.55	2.30	2.70	5.20
7	6.50	4.50	5.10	5.35	4.00	2.15	1.50	1.50	1.55	2.30	2.60	5.00
8	6.30	4.60	4.80	6.00	4.00	2.15	1.60	1.55	1.55	2.25	2.70	4.80
9	6.05	.....	4.70	6.20	3.80	2.15	1.60	1.60	1.55	2.20	2.85	4.60
0	5.90	.....	4.80	5.90	3.60	2.20	1.60	1.65	1.50	2.10	3.60	4.40
1	5.70	.....	5.00	.....	3.45	.....	1.60	1.65	.....	2.10	.....	4.10

BLACKFOOT RIVER AT BONNER, MONTANA.

This river has its source on the western slope of the main divide of the Rocky Mountains in Deerlodge County. Its drainage basin is mountainous and well wooded, and little cultivation is possible within the area. The Clearwater Lakes near the head serve as a reservoir, giving the stream a relatively constant flow. The principal industrial applications of the river are found near its mouth, where the water can be used for power purposes as well as for the irrigation of the adjacent lands. Measurements at this point are affected to a certain extent by the dam of the Big Blackfoot Milling Company, which is located about 1,000 yards above the station, and which furnishes water for the mills and electric-power stations. The opening and closing of the flood gates of the dam cause abrupt changes in the recorded gage heights. The station, established July 7, 1898, is located at the wagon bridge one-half mile west of Bonner and 6 miles east of Missoula. The rod of the wire gage is fastened to the upper side of the bridge. Bench mark No. 1, established by the Topographic Division of the United States Geological Survey, is a cross cut by a chisel on the top and northeast corner of the northeast buttress of the Northern Pacific railway bridge over Big Blackfoot River near Bonner, and is at an elevation above sea of 3,290.298 feet. Bench mark No. 2 is a regulation United States Geological Survey iron post on the east side of the river, 10 yards south of the highway and 20 yards north of Mr. McCormick's house, outside of dooryard fence, and at an elevation of 3,246.038 feet. The elevation of the axle of the pulley of the wire gage is 3,251.678 feet. The length of the wire gage is 22.75 feet. This gage was verified June 10, 1899, and September 8, 1899, when a stretch of the cable or a movement of the index of 0.55 foot was found to have occurred. The results of measurements for 1898 may be found in the Twentieth Annual Report, Part IV, page 491. The following measurements of discharge for 1899 were made under the direction of F. D. Smith:

Discharge measurements of Blackfoot River at Bonner, Montana.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
January 28	1.20	1,026	July 17	4.10	4,042
April 22	2.58	2,420	July 29	2.68	2,848
May 13	5.30	9,253	August 25	1.65	1,578
June 12	7.40	13,873	September 8	1.17	1,235
June 20	8.70	17,324	October 21	1.05	1,188

Daily gage height, in feet, of Blackfoot River at Bonner, Montana, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	0.75	.....	0.25	2.45	6.90	6.65	2.65	1.40	1.00	0.95	0.95
2	.....	.....	.....	.20	2.35	6.90	6.35	2.50	1.35	.95	1.00	1.45
3	.....	.....	1.65	.20	2.35	7.50	6.10	2.40	1.45	.95	.90	.80
4	.....	.....	1.40	.35	2.25	8.00	6.00	2.35	1.50	1.00	.90	.70
5	.....	.....	.85	.45	2.30	8.35	5.85	2.35	1.40	.75	1.15	.90
6	.....	.....	1.10	.60	2.55	8.00	5.60	2.30	1.40	.90	.95	.70
7	.....	.....	.85	.80	3.00	7.35	5.40	2.25	1.35	.85	.95	.85
8	.....	.....	.85	.80	3.45	6.75	5.35	2.20	1.35	.85	.95	.85
9	.....	.....	.60	1.10	4.10	6.30	5.35	2.20	1.35	.85	.90	.85
10	.....	.....	.50	2.30	5.00	6.15	5.35	2.15	1.30	.90	.90	.65
11	.....	.....	.55	3.35	5.30	6.55	5.25	2.15	1.25	1.00	.90	.70
12	.....	.....	.45	3.65	5.55	7.55	5.05	2.10	1.20	.85	.95	.75
13	.....	.....	.50	4.80	5.35	7.55	4.90	2.00	1.25	.90	.95	.70
14	.....	.....	.60	3.95	5.25	7.20	4.65	1.95	1.40	.80	.95	.75
15	.....	.....	.50	3.10	4.95	6.80	4.40	1.85	1.30	.90	.95	.60
16	.....	.....	.55	3.05	4.70	6.80	4.30	1.80	1.20	.90	.95	.55
17	.....	.....	.40	2.75	4.70	7.25	4.10	1.85	1.15	.95	.95	.50
18	.....	.....	.55	2.65	4.70	7.85	4.00	1.80	1.10	.95	.85	.75
19	.....	.....	.25	2.55	4.85	8.55	3.85	1.75	1.15	.90	1.25	.90
20	.....	.90	.35	2.25	4.80	8.70	3.90	1.75	1.30	.95	.90	1.00
21	.....	.65	.30	2.45	4.85	8.45	3.75	1.75	1.10	1.15	.90	.85
22	0.65	1.65	.25	2.67	4.85	7.75	3.55	1.75	1.05	1.00	.95	.95
23	.60	.....	.35	2.80	5.05	7.10	3.55	1.95	1.00	1.00	.90	.85
24	.85	.....	.35	2.45	5.25	6.80	3.25	1.80	.90	1.05	.80	1.15
25	.70	.....	.40	2.45	6.20	6.65	3.10	1.70	1.10	.95	.95	1.10
26	.75	.....	.20	3.05	7.10	6.95	3.05	1.65	1.00	1.00	1.05	1.15
27	1.00	.....	.30	3.25	7.65	7.10	2.80	1.65	1.05	.95	.95	.95
28	1.05	.....	.15	3.05	7.60	6.65	2.75	1.70	1.00	.95	.85	.75
29	.95	.....	.20	2.80	7.10	6.55	2.70	1.65	1.05	.95	.90	.50
30	.90	.....	.30	2.60	7.25	6.80	2.70	1.45	.90	.95	.80	.55
31	1.00	.....	.20	.....	7.00	.....	2.65	1.45	.....	1.00	.....	.70

RATTLESNAKE CREEK AT MISSOULA, MONTANA.

This is a stream having its source north of Missoula and draining a all extent of country. It enters Missoula River in the city of Mis- la. The most important application of this stream is by the Mis- la waterworks, for the water supply of the city of Missoula. About second-feet are used for this purpose. Twelve ditches, with a acity of from 1 to 10 second-feet each, divert water from the creek l irrigate lands in Rattlesnake Valley and in the vicinity of Missoula. other ditch, with a capacity of 20 second-feet, diverts water from mouth of the stream and is used for power purposes in a cabinet p in the town of Missoula. At a medium stage of water in 1899 s stream was carrying 108 second-feet above the ditch diversions. the same time it was discharging into Missoula River 45 second- t, the difference, 63 second-feet, being used for power and irriga- n purposes. The station was established May 27, 1899, and is located the Ivy street bridge in the center of the city. The bench mark is top of the capstone of the stone steps of the house owned by omas Greenough, 25 yards southeast from the gage and 1.983 feet ve center of axle of the pulley of the gage. Between May 27 and tember 7 a stretch of 0.15 foot was noticed, and the records, as blished, have been correspondingly corrected.

The following discharge measurements were made during 1899 under the direction of Prof. F. D. Smith:

Discharge measurements of Rattlesnake Creek at Missoula, Montana.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
May 30	4.55	653	July 28	3.20	124
June 12	6.05	1,712	August 22	2.85	63
June 17	5.70	1,695	September 7	2.85	68
July 4	5.00	1,097	September 28	2.60	47
July 12	4.30	570			

Daily gage height, in feet, of Rattlesnake Creek at Missoula, Montana, for 1899.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	4.35	5.00	2.98	2.68	2.53	2.85	2.88
2	.....	4.65	5.13	2.98	2.68	2.50	2.85	2.98
3	.....	4.90	5.03	2.95	2.73	2.50	2.83	3.00
4	.....	5.03	4.95	2.90	2.90	2.50	2.80	3.00
5	.....	4.98	5.00	2.80	2.80	2.50	2.93	2.98
6	.....	4.60	4.78	2.73	2.83	2.50	2.75	2.95
7	.....	4.35	4.70	2.68	2.83	2.50	2.75	2.93
8	.....	4.20	4.70	2.78	2.78	2.50	2.73	2.93
9	.....	4.23	4.70	2.88	2.80	2.55	2.70	2.90
10	.....	4.70	4.58	2.88	2.73	2.58	2.75	2.88
11	.....	6.05	4.50	2.85	2.68	2.55	2.83	2.85
12	.....	5.95	4.38	2.80	2.70	2.58	2.88	2.80
13	.....	5.20	4.30	2.75	2.80	2.58	2.85	2.80
14	.....	4.85	4.18	2.78	2.80	2.50	2.80	2.73
15	.....	4.68	4.10	2.75	2.80	2.58	2.78	2.35
16	.....	5.18	3.98	2.75	2.80	2.58	2.75	2.30
17	.....	5.90	3.80	2.70	2.78	2.65	2.75	(a)
18	.....	6.25	3.83	2.68	2.75	2.63	2.75	(a)
19	.....	6.18	3.73	2.63	2.73	2.65	2.75	(a)
20	.....	6.05	3.63	2.65	2.68	2.90	2.75	(a)
21	.....	5.12	3.60	2.78	2.68	2.93	2.75	(a)
22	.....	4.83	3.60	2.80	2.65	2.90	2.70	(a)
23	.....	4.70	3.53	2.85	2.60	2.90	2.73	(a)
24	.....	5.00	3.43	2.83	2.60	2.88	2.68	2.90
25	.....	5.40	3.40	2.75	2.55	2.88	2.65	2.95
26	.....	5.73	3.35	2.78	2.55	2.85	2.70	3.05
27	5.15	5.35	3.33	2.83	2.55	2.85	2.73	3.00
28	4.78	5.05	3.23	2.73	2.55	2.88	2.98	2.90
29	4.45	5.35	3.13	2.68	2.55	2.90	3.05	3.00
30	4.65	5.33	3.03	3.65	2.53	2.85	3.03	2.85
31	4.40	.....	3.08	2.68	.....	2.85	.....	.....

a December 17 to 23 no readings.

MISSOULA RIVER AT MISSOULA, MONTANA.

This river has its source in Silverbow County and flows northerly until it receives the waters of Little Blackfoot River, when it takes a more northwesterly course. The name Missoula is usually applied to that section of the river between the junction of Blackfoot and Hellgate rivers and the mouth of Pend Oreille River. The name usually applied to it from this point down to its junction with Columbia River is Clark Fork of the Columbia. The station, established July 10, 1898, is located at Higgins avenue bridge in Missoula. The river at this point flows in two channels, and in order to study their fluctuations a second rod was placed on the south channel January 28, 1899.

his second rod is vertical and attached to the pier of the bridge. The eadings of the two rods were made to correspond on the date of the stablishment of the second rod, and they were 2.85 feet. The riginal rod is known as rod No. 1, and the gage in the south channel s known as rod No. 2. Discharge measurements are always made t the bridge of the Bitterroot Valley division of the Northern Pacific ailway some distance below the Higgins avenue bridge. The river t this point is practically in one channel, except in times of flood, hen some water finds its way through a slough 600 feet south of he bridge. On account of the difficulty of accurately measuring he fluctuations of the river at rods Nos. 1 and 2 a third rod was laced May 27, 1899, below the junction of the two branches and 50 yards east of the railroad bridge. The rod at this point conists of a horizontal 20-foot timber bolted to a cottonwood tree immeiately below the buildings of the Garden City Bottling Works. he rod is securely braced with timbers both above and below and uyed by wires on both sides. To the horizontal timber is attached wire gage, the length of which is 22 feet. The bench mark conists of a United States Geological Survey iron post, at the junction f McCormick and West Cedar streets, 100 yards west of the gage, on he north side of the highway. Its elevation above sea is 3,194.642 eet. The top of the horizontal bar of the gage at a point exactly ver the iron bolt which holds the rod to the cottonwood tree is ,178.338 feet. The height of the river was read at the three rods luring 1899, but observations during 1900 will only be taken at rod No. 3, the other two being discontinued. The results of measurenents for 1898 may be found in the Twentieth Annual Report, Part V, page 491. Measurements for 1898 and 1899 were made under the lirection of F. D. Smith and are as follows:

Discharge measurements of Missoula River at Missoula, Montana.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
April 22	a 4.75	6,876	August 1	5.35	4,822
May 30	9.50	23,295	August 24	4.75	3,127
June 19	10.55	34,634	September 8	4.15	2,492
July 6	8.30	17,872	October 21	4.10	2,273
July 14	7.30	9,235			

a Gage height at rod No. 1. The other gage heights were taken on rod No. 3.

Daily gage height, in feet, of Missoula River at Missoula, Montana, for 1899.

[Rod No. 1.]

Day.	Jan.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	.....	2.33	4.15	9.10	8.90	4.35	3.33	2.95
2	.....	.....	2.35	4.15	8.95	8.50	4.30	3.30	2.95
3	.....	.....	2.40	3.95	9.60	8.30	4.28	3.33	2.95
4	.....	.....	2.50	3.80	10.10	8.15	4.20	3.38	2.95
5	.....	.....	2.70	3.80	10.50	8.00	4.20	3.38	2.95
6	.....	.....	3.00	4.15	10.30	7.75	4.08	3.33	2.95
7	.....	2.30	3.33	4.50	9.60	7.38	4.00	3.20	2.95
8	.....	2.35	3.63	5.10	8.80	7.35	4.00	3.20	2.95
9	.....	2.48	3.73	5.75	8.35	7.40	4.03	3.15	2.95
10	.....	2.50	4.87	6.70	8.40	7.33	4.05	3.15	2.95
11	.....	2.55	5.85	7.05	9.15	7.25	4.00	3.13	2.95
12	.....	2.58	6.20	7.30	10.08	6.93	3.95	3.10	2.95
13	.....	2.60	7.60	7.15	9.90	6.75	3.93	3.10	3.00
14	.....	2.38	6.40	6.95	9.65	6.50	3.95	3.10	2.98
15	.....	.....	4.95	6.65	9.43	6.38	3.90	3.10	2.93
16	.....	2.15	4.95	6.45	9.45	6.23	3.80	3.10	2.98
17	.....	2.15	4.78	6.40	9.85	5.90	3.75	3.03	3.00
18	.....	2.20	4.55	6.40	10.60	5.65	3.70	3.00	3.00
19	.....	2.18	4.40	6.35	10.90	5.48	3.68	3.00	2.98
20	.....	2.28	4.05	6.45	11.30	5.43	3.63	2.95	3.00
21	.....	2.25	3.98	6.50	10.73	5.38	3.63	2.95	3.03
22	.....	2.20	4.53	6.55	10.10	5.30	3.70	2.95	3.03
23	.....	2.15	4.70	6.75	9.35	5.15	3.75	2.95	3.00
24	.....	2.28	4.35	7.05	8.95	4.90	3.73	2.95	3.00
25	.....	2.35	4.28	8.00	9.05	4.73	3.70	2.95	3.05
26	.....	2.35	4.83	9.10	9.50	4.68	3.63	2.95	3.00
27	.....	2.48	4.95	9.80	9.70	4.60	3.55	2.95	3.05
28	.....	2.58	4.70	9.75	9.15	4.53	3.50	2.90	3.00
29	2.80	2.53	4.45	9.35	9.00	4.50	3.50	2.90	2.95
30	2.75	2.40	4.25	9.30	9.10	4.40	3.45	2.90	2.93
31	2.75	2.30	.....	9.15	.....	4.30	3.43	.....	2.90

No record for February; ice. Station discontinued October 31.

Daily gage height, in feet, of Missoula River at Missoula, Montana, for 1899.

[Rod No. 2.]

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	.....	2.50	3.80	7.60	7.25	3.83	3.20	2.95
2	.....	2.50	3.70	7.28	6.93	3.88	3.20	2.95
3	.....	2.55	3.60	7.80	6.78	3.83	3.23	2.95
4	.....	2.60	3.50	8.20	6.65	3.75	3.20	2.95
5	.....	2.75	3.60	8.60	6.55	3.78	3.20	2.95
6	.....	2.90	4.00	8.45	6.35	3.73	3.15	2.95
7	.....	3.10	4.20	7.65	7.13	3.63	3.15	2.95
8	.....	3.30	4.60	7.15	6.00	3.65	3.15	2.95
9	.....	3.50	5.30	6.85	6.00	3.65	3.13	2.95
10	.....	4.70	5.60	6.75	6.00	3.70	3.05	3.00
11	2.50	5.30	6.00	7.40	5.98	3.68	3.03	3.05
12	2.58	5.30	6.20	8.35	5.83	3.60	3.00	3.05
13	2.60	6.20	5.90	8.35	5.55	3.60	3.00	3.08
14	(a)	4.80	5.75	7.90	5.48	3.65	3.00	3.05
15	(a)	4.30	5.60	7.43	5.40	3.53	3.05	2.93
16	(a)	4.50	5.50	7.45	5.20	3.45	3.03	3.03
17	2.40	4.20	5.40	7.80	5.00	3.45	3.05	3.05
18	2.28	4.20	5.30	8.65	4.80	3.40	3.00	3.05
19	2.28	3.90	5.30	8.80	4.73	3.35	3.00	3.03
20	2.40	3.70	5.40	8.90	4.54	3.40	2.98	3.15
21	(a)	3.70	5.40	8.85	4.50	3.40	2.95	3.08
22	(a)	4.20	5.50	8.40	4.48	3.48	2.95	3.10
23	(a)	4.10	5.70	7.90	4.43	3.50	2.95	3.05
24	2.40	3.90	5.80	7.45	4.28	3.45	5.95	3.10
25	2.45	4.00	6.80	7.50	4.20	3.43	2.95	3.05
26	2.55	4.30	7.60	8.05	4.00	3.38	2.98	3.05
27	2.60	4.40	8.00	7.80	4.00	3.33	2.95	3.10
28	2.55	4.10	7.80	7.48	3.90	3.30	2.90	3.05
29	2.61	3.90	7.40	7.40	3.90	3.30	2.90	3.00
30	2.50	3.80	7.50	7.48	3.85	3.25	2.90	2.98
31	2.45	.....	7.50	.....	3.85	3.23	.....	2.95

a Ice. Station discontinued October 31.

ily gage height, in feet, of Missoula River at Missoula, Montana, for 1899.

[Rod No. 3.]

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	.....	9.30	9.30	5.40	4.25	3.78	3.98	3.95
.....	.....	9.22	8.95	5.35	4.23	3.75	3.95	3.93
.....	.....	9.60	8.75	5.25	4.28	3.75	3.90	3.88
.....	.....	10.00	8.60	5.10	4.33	3.75	3.95	3.60
.....	.....	10.23	8.55	5.08	4.33	3.75	3.95	3.53
.....	.....	10.05	8.33	4.98	4.25	3.75	3.98	3.60
.....	.....	10.38	8.13	4.83	4.18	3.75	3.93	3.60
.....	.....	9.10	8.05	4.95	4.15	3.75	3.90	3.65
.....	.....	8.73	8.03	5.08	4.13	3.75	3.95	3.75
.....	.....	8.78	8.00	5.15	4.10	3.75	3.93	3.70
.....	.....	9.38	7.93	5.12	4.08	3.80	3.90	3.70
.....	.....	10.05	7.73	5.00	4.05	3.80	3.93	3.75
.....	.....	10.05	7.58	4.90	4.05	3.88	3.98	3.80
.....	.....	9.73	7.38	4.93	4.05	3.80	3.95	3.80
.....	.....	9.43	7.20	4.78	4.08	3.68	3.98	3.30
.....	.....	9.23	6.95	4.73	4.08	3.88	3.88	.....
.....	.....	9.80	6.88	4.65	4.05	3.95	3.88	.....
.....	.....	10.38	6.70	4.58	4.00	3.98	3.90	.....
.....	.....	10.55	6.48	4.53	4.00	4.03	3.90	.....
.....	.....	10.65	6.43	4.70	3.93	4.10	3.90	.....
.....	.....	10.45	6.33	4.65	3.90	4.10	3.95	.....
.....	.....	10.03	6.23	4.73	3.90	4.20	3.90	.....
.....	.....	8.95	6.13	4.85	3.85	4.15	3.88	.....
.....	.....	9.30	5.98	4.75	3.75	4.18	3.83	.....
.....	.....	9.30	5.83	4.65	3.80	4.10	3.75	.....
.....	.....	9.58	5.68	4.52	3.78	4.08	3.65	.....
.....	9.85	9.65	5.50	4.50	3.73	4.15	3.75	.....
.....	9.80	9.38	5.45	4.50	3.75	4.05	3.88	.....
.....	9.55	9.25	5.45	4.48	3.75	4.00	3.98	.....
.....	9.55	9.33	5.40	4.38	3.75	3.98	3.95	.....
.....	9.45	.....	5.40	4.28	.....	3.95	.....	.....

BITTERROOT RIVER AT COMO, MONTANA.

nain source of supply of this river is in the high mountains ; the boundary line between Montana and Idaho. The gen- ection of the stream is northerly, entering Missoula River a istance below the city of Missoula. The tributaries on the e drain comparatively low hills and contribute little to the of the river. The west-side branches, on the contrary, are us, draining a precipitous and heavily wooded area. Their ;es are regulated by many small lakes fed by banks of snow ontinue far into the summer season before disappearing alto-

In the vicinity of Hamilton are a number of large canals, the ıl ones diverting water on the east side of the river for use by erroot Stock Farm. The higher bench lands west of the river ed by small ditches taken directly from the smaller tributaries. ıchers on these bench lands have within the last few years ›d the summer flow of their ditches by the construction of rude the outlets of a number of the lakes on the headwaters of the eams. This is done at the heads of Canyon, Bear, and Big

An additional supply can be had by utilizing Lake Como. :e is about 1 mile long and one-half mile wide and is near the ›f Rock Creek. The gaging station, established by Cyrus C.

Babb in October, 1898, is located at the Harlan bridge near Como, and is 9 miles south of Grantsdale, Montana. A wire gage was placed on the downstream hand-rail of the bridge, and later a vertical rod was fastened to the upstream side of the south pier. The bench mark is on a cottonwood tree 10 feet west of the south end of the bridge, and is at an elevation of 6.10 feet above gage datum. The right bank of the river is high, while the left bank is low and liable to overflow. Gage readings have not yet been maintained at this point, and but one discharge measurement was made during 1899. H. S. Lord, on January 21, 1899, at a gage height of 1 foot, found a discharge of 384 second-feet.

BITTERROOT RIVER AT MISSOULA, MONTANA.

The fall of this river from Hamilton to Missoula, a distance of 48 miles, is 350 feet, or 7.3 feet to the mile. The lower portion of Bitterroot Valley has not been as extensively cultivated as the section in the vicinity of Hamilton. There is a good flow of water in the river, but owing to the lighter grade of the lower country a greater length of canal is necessary than in the upper section, and therefore this latter district has been first developed. The gaging station is located at the Buckhouse wagon bridge, on the main road southwest of Missoula, and was established July 6, 1898. The bench mark is the regulation iron post of the United States Geological Survey, set 25 yards northwest of the bridge, near a fence at the side of the highway, and is 3.801 feet above the center of the axle of the gage pulley. The length of the gage wire is 22.83 feet. The channel of the river is nearly straight. The right bank is low and liable to overflow, but the left bank is high and rocky. The results obtained at the Buckhouse bridge, which is near the mouth of the river, are of value mainly in giving the total discharge of the stream. The results of measurements for 1898 may be found in the Twentieth Annual Report, Part IV, page 495. The following measurements of discharge were made under the direction of F. D. Smith in 1899:

Discharge measurements of Bitterroot River at Missoula, Montana.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
April 29	3.75	3,794	July 17	7.21	11,509
May 16	5.18	7,405	August 1	4.55	5,419
June 10	6.70	11,732	August 25	2.78	2,595
June 17	9.00	20,355	October 21	2.18	1,810
June 20	11.40	37,012			

Daily gage height, in feet, of Bitterroot River at Missoula, Montana, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	(a)	1.25	1.55	3.50	6.80	9.60	4.55	2.40	1.55	2.30	1.90
2	(a)	(a)	1.25	1.70	3.40	6.70	9.55	4.50	2.35	1.60	2.15	2.00
3	(a)	(a)	1.30	1.75	3.20	7.15	9.40	4.30	2.40	1.70	2.05	2.00
4	(a)	(a)	1.35	1.80	3.10	8.30	9.20	4.10	2.50	1.70	2.00	1.80
5	(a)	(a)	1.40	1.80	3.00	8.90	9.10	4.00	2.60	1.65	2.00	1.80
6	(a)	(a)	1.45	1.95	3.30	8.00	9.05	4.05	2.50	1.60	2.00	1.90
7	(a)	(a)	1.50	1.95	3.45	7.20	8.75	4.00	2.45	1.60	2.00	1.94
8	(a)	(a)	1.70	2.05	3.90	6.80	8.70	4.05	2.30	1.55	1.95	1.95
9	(a)	(a)	1.65	2.15	4.90	6.70	8.85	4.10	2.25	1.55	1.95	1.96
10	(a)	(a)	1.60	2.50	5.93	6.75	8.95	4.15	2.20	1.60	2.00	1.80
11	(a)	(a)	1.55	2.80	6.30	7.95	8.90	4.10	2.10	1.60	2.00	1.80
12	(y)	(a)	1.45	3.20	6.45	9.40	8.85	4.00	2.05	1.60	2.05	1.85
13	(a)	(a)	1.40	3.80	6.40	10.80	8.60	3.70	2.10	1.65	2.00	1.75
14	(a)	(a)	1.35	3.65	6.25	10.50	8.10	3.50	2.30	1.65	1.95	1.75
15	(a)	(a)	1.40	3.45	6.00	9.20	7.75	3.40	2.25	1.70	1.90	1.80
16	(a)	(a)	1.40	3.50	5.20	8.50	7.50	3.25	2.25	1.70	1.95	(a)
17	1.50	(a)	1.35	3.50	5.00	8.98	7.50	3.05	2.15	1.75	2.00	(a)
18	1.55	(a)	1.40	3.60	4.70	9.90	7.20	3.00	2.10	1.80	2.00	(a)
19	1.55	(a)	1.40	3.65	4.65	10.95	7.15	2.85	2.10	1.80	2.00	(a)
20	1.60	(a)	1.40	3.45	4.60	11.45	7.00	3.50	2.00	1.90	1.90	(a)
21	1.65	(a)	1.40	3.40	4.60	11.28	6.95	2.95	1.90	2.10	1.85	(a)
22	1.65	(a)	1.40	3.30	4.60	11.13	6.60	3.10	1.80	2.25	1.85	(a)
23	1.70	(a)	1.35	3.50	5.00	9.65	5.95	3.20	1.80	2.40	1.80	(a)
24	1.70	(a)	1.55	3.70	5.48	9.40	5.50	3.00	1.75	2.30	1.75	(a)
25	1.65	(a)	1.55	3.75	5.90	9.10	5.15	2.85	1.75	2.25	1.70	1.65
26	1.70	(a)	1.60	3.80	7.40	9.80	5.00	2.75	1.65	2.30	1.60	1.65
27	1.80	(a)	1.65	3.95	7.95	10.20	4.85	2.70	1.60	2.50	1.70	1.60
28	1.80	(a)	1.65	4.00	7.70	9.90	4.80	2.65	1.60	2.55	1.80	1.60
29	(a)	.....	1.65	3.75	7.30	9.60	4.75	2.60	1.65	2.60	1.90	1.68
30	(a)	.....	1.65	3.60	7.50	9.85	4.75	2.50	1.55	2.55	1.90	1.70
31	(a)	.....	1.60	.....	6.95	.....	4.60	2.45	.....	2.40	.....	1.70

a Frozen.

SPOKANE RIVER AND LAKE CŒUR D'ALENE.

This river receives the outflow of Lake Cœur d'Alene, the outlet ng at the northern end of the lake near the town of Cœur d'Alene. e greater part of the lake is shown on the topographic atlas sheet the same name. The bench mark near the lake was established by ·. Van H. Manning in 1899. From his notes it appears that this bench rk, consisting of an aluminum tablet in the southeast corner of the erriam Building, corner of Sherman and Fourth streets, Cœur lene, Idaho, is 2 feet above the sidewalk and 1 foot from the door, an elevation of 2,157.404 feet. The bench mark at the lake con ts of a spike in a cottonwood tree at Johnson's boat landing. This at an elevation of 2,130.645 feet. When placed, May 20, 1899, it s at the exact surface of the water of the lake. The fluctuations lake level during 1899 are shown by the following readings by Mr. anning:

Elevation of water surface of Lake Cœur d'Alene.

1899.

Date.	Elevation.
	Feet.
May 20	2,130.645
May 23	2,130.000
July 3	2,128.242
July 24	2,128.643
August 5 (5 p. m.)	2,122.551
August 23	2,121.469

The level of the water in the lake is influenced by a dam at Post Falls, 8¾ miles below the outlet of the lake. On August 5, at 3.30 p. m., the elevation of the surface of the water at the dam at Post Falls was 2,119.580 feet. Observations were made on the same day, at 5 p. m., at Cœur d'Alene, giving the elevation of water surface above noted—2,122.551 feet—and showing a difference of 2.971 feet between the lake surface and the water in the river at the dam. It is proposed to maintain occasional observations of the height of water at Cœur d'Alene.

Fernan Lake is a small body of water 2 miles east of the town of Cœur d'Alene. A bench mark has been established at the west end of the lake on a stone about 20 inches by 30 inches, 20 inches in diameter, 15 feet north of and 200 feet east of Fernan's house. The cross on this stone is at an elevation of 2,133.16 feet. The surface of the lake on August 18, 1899, was at a height of 2,129.028 feet.

Hayden Lake is east of Rathdrum Prairie and about 6 miles north of Cœur d'Alene. Although a body of water of considerable size and receiving drainage from a mountain area it has no visible outlet. A bench mark has been placed at the west end of the lake and consists of a nail in a pine tree 40 feet north of and 200 feet east of gate to King's ranch. Its elevation is 2,261.495 feet. The surface of the lake on August 10, 1899, was 2,242.764 feet; on August 29, 2,242.666 feet; on October 10, 2,241.369 feet.

Spirit Lake is a small body of water 12 miles north of Rathdrum Prairie. An iron post marked "2,490 S" has been placed at the east end of the lake, 200 feet east of the landing and 15 feet south of the road. The correct elevation is 2,489.993 feet. The elevation of the lake surface on September 14, 1899, was 2,444.037 feet.

Fish Lake is 3 miles north of Rathdrum. An iron post marked "2,366 S" has been placed one-fourth of a mile east of the south end of the lake and 8 feet east of the fork of the roads. The elevation is 2,365.706 feet. The elevation of lake surface on September 4, 1899, was 2,314.016 feet. Irrigation of Rathdrum Prairie has been begun by the Spokane Valley Irrigation Company.

Pend Oreille Lake is the source of Clark Fork of the Columbia. The elevation of its surface on September 22, 1899, as determined by Mr. Van H. Manning, was 2,055 feet.

SPOKANE RIVER AT SPOKANE, WASHINGTON.

The falls at Spokane, aggregating 142 feet in height, have been utilized to a considerable extent by a number of flour mills, as well as by the power plant of the Washington Water Power Company, which furnishes electric power for the street-car service and for the lighting of the city. The river station established October 17, 1896, is located a short distance above the falls, at the bridge of the Oregon Railroad and Navigation Company. The length of the wire gage is 22 feet. The gage was connected with the bench mark of the city engineering

epartment and referred to sea level, the zero being 1,880 feet above ea level. The banks are high and do not overflow except in unusual oods. The velocity is quite swift, even at low stages. The results f measurements may be found as follows: 1896, Eighteenth Annual eport, Part IV, page 359; 1897, Nineteenth Annual Report, Part IV, age 488; 1898, Twentieth Annual Report, Part IV, page 511. One easurement of discharge was made here during 1899 by Sydney rnold, on June 23, when at a gage height of 9.30 feet a discharge of 3,258 second-feet was found.

Daily gage height, in feet, of Spokane River at Spokane, Washington, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.40	5.50	3.75	3.65	8.65	10.60	8.30	3.75	2.40	2.00	2.40	3.95
2	2.50	5.40	3.75	3.70	8.50	10.55	8.20	3.75	2.40	2.00	2.40	4.50
3	2.60	5.25	3.75	3.75	8.40	10.40	8.00	3.75	2.40	2.00	2.40	5.00
4	2.60	5.10	3.70	3.80	8.20	10.45	7.80	3.70	2.40	2.00	2.40	5.30
5	2.60	5.00	3.65	3.90	8.00	10.60	7.60	3.70	2.40	2.00	2.35	5.35
6	2.55	4.85	3.65	4.00	7.90	10.70	7.40	3.60	2.40	1.90	2.35	5.40
7	2.55	4.70	3.60	4.10	7.70	10.65	7.15	3.50	2.40	1.90	2.35	5.35
8	2.50	4.60	3.60	4.35	7.80	10.50	7.05	3.40	2.40	1.95	2.35	5.25
9	2.50	4.50	3.65	4.45	8.05	10.35	6.85	3.30	2.40	1.95	2.35	5.20
10	2.50	4.40	3.70	4.85	8.55	10.10	6.70	3.30	2.40	1.90	2.35	5.10
11	2.50	4.30	3.80	5.05	9.00	10.00	6.50	3.25	2.40	1.90	2.35	4.90
12	2.50	4.20	3.85	5.45	9.45	9.85	6.40	3.10	2.30	1.90	2.30	4.85
13	2.50	4.10	3.85	6.20	9.90	9.89	6.30	3.00	2.30	1.90	2.30	4.75
14	2.50	4.05	3.85	6.90	10.20	9.85	6.20	2.95	2.30	1.90	2.30	4.70
15	2.60	4.00	3.85	7.40	10.35	9.85	6.10	2.90	2.30	1.90	2.30	4.65
16	2.60	3.90	3.85	..50	10.35	9.75	5.85	2.85	2.30	1.90	2.30	4.55
17	2.60	3.90	3.85	7.85	10.20	9.60	5.70	2.85	2.30	1.90	2.30	4.40
18	2.60	3.85	3.80	8.00	10.10	9.60	5.60	2.80	2.30	1.90	2.30	4.25
19	2.60	3.85	3.70	8.20	10.00	9.70	5.25	2.75	2.25	1.90	2.50	4.10
20	2.85	3.90	3.65	8.30	9.85	9.74	5.05	2.75	2.20	1.95	2.50	4.00
21	2.95	3.95	3.65	8.30	9.70	9.70	4.90	2.75	2.20	2.00	2.65	3.90
22	3.65	3.95	3.70	8.25	9.50	9.60	4.75	2.75	2.15	2.10	2.80	3.85
23	4.55	3.90	3.70	8.20	9.50	9.50	4.65	2.75	2.15	2.20	2.85	3.80
24	5.20	3.90	3.70	8.20	9.50	9.40	4.50	2.65	2.15	2.25	2.90	3.90
25	5.60	3.90	3.70	8.15	9.70	9.30	4.45	2.60	2.10	2.30	2.90	4.15
26	5.55	3.90	3.70	8.15	9.95	9.15	4.30	2.60	2.10	2.35	2.90	4.50
27	5.55	3.80	3.65	8.35	10.25	8.85	4.20	2.55	2.10	2.35	3.00	4.75
28	5.55	3.80	3.60	8.60	10.55	8.55	4.00	2.55	2.10	2.35	3.00	4.90
29	5.55	.....	3.60	8.70	10.80	8.50	3.90	2.55	2.05	2.35	3.20	4.90
30	5.55	.....	3.60	8.70	10.80	8.40	3.80	2.50	2.05	2.35	3.50	4.80
31	5.60	.....	3.65	.....	10.80	.....	3.75	2.45	.....	2.40	.....	4.70

LAKE CHELAN AT LAKESIDE, WASHINGTON.

This lake is situated in the north-central part of Washington, on the astern slope of the Cascade Mountains. The streams which contribte to it have their sources in the glaciers, and thus there is a constant upply. The outlet of the lake is at the southern extremity, through helan River, which empties into Columbia River 4 miles below. The ake itself is very deep, a depth of 1,400 feet having been found by oundings made by the topographers of the United States Geological urvey. As the surface of the lake is at an elevation of about 1,100 eet, this would show that the bottom was about 300 feet below sea evel. The country surrounding the lower extremity of this body of vater is of a rolling character and is largely used for grazing purposes. The gage on the lake was established by Capt. Charles John-on September 1, 1897, at the base of the rock pier on the lake shore orth of his house, about one-half mile from the steamboat landing.

The bench mark is a United States Geological Survey iron post, with the elevation—1,121 feet above sea level—stamped on the top. This bench mark is just 21 feet above datum of the gage, so that to obtain the elevation of the surface of the lake above sea level 1,100 feet should be added to the rod readings.

Daily gage height, in feet, of Lake Chelan at Lakeside, Washington, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.10	7.85	7.35	6.85	7.40	10.10	11.60	10.90	8.45	7.70	7.05	7.90
2	7.20	7.85	7.35	6.90	7.45	10.10	11.55	10.85	8.40	7.70	7.10	7.95
3	7.30	7.80	7.30	6.90	7.45	10.20	11.55	10.80	8.40	7.70	7.20	7.95
4	7.35	7.75	7.30	6.90	7.45	10.40	11.60	10.65	8.35	7.65	7.25	7.95
5	7.35	7.70	7.30	6.95	7.50	10.60	11.65	10.60	8.35	7.65	7.30	8.00
6	7.40	7.65	7.25	6.95	7.50	10.65	11.70	10.60	8.30	7.60	7.35	8.00
7	7.45	7.60	7.25	7.00	7.55	10.65	11.70	10.55	8.25	7.55	7.40	8.05
8	7.45	7.60	7.25	7.00	7.65	10.70	11.60	10.50	8.25	7.50	7.45	8.05
9	7.50	7.55	7.20	7.05	7.85	10.70	11.55	10.40	8.20	7.50	7.50	8.10
10	7.50	7.50	7.20	7.10	8.00	10.75	11.55	10.30	8.15	7.45	7.55	8.10
11	7.45	7.50	7.15	7.10	8.20	10.85	11.60	10.20	8.10	7.40	7.55	8.15
12	7.45	7.45	7.15	7.15	8.30	11.00	11.60	10.10	8.10	7.35	7.60	8.15
13	7.40	7.45	7.15	7.15	8.40	11.10	11.65	10.05	8.05	7.30	7.65	8.20
14	7.45	7.40	7.10	7.15	8.45	11.15	11.70	10.00	8.05	7.25	7.65	8.20
15	7.45	7.35	7.10	7.20	8.50	11.20	11.75	9.85	8.00	7.25	7.70	8.20
16	7.45	7.35	7.05	7.20	8.50	11.35	11.75	9.75	8.00	7.20	7.75	8.25
17	7.50	7.30	7.05	7.25	8.55	11.60	11.80	9.65	7.95	7.15	7.80	8.25
18	7.50	7.30	7.00	7.25	8.55	11.65	11.80	9.60	7.95	7.15	7.85	8.20
19	7.55	7.30	7.00	7.25	8.60	11.65	11.75	9.50	7.90	7.10	7.90	8.20
20	7.60	7.35	7.00	7.25	8.65	11.70	11.70	9.40	7.90	7.10	7.90	8.25
21	7.60	7.35	6.95	7.30	8.70	11.65	11.65	9.35	7.90	7.05	7.95	8.25
22	7.60	7.35	6.95	7.30	8.80	11.60	11.60	9.30	7.90	7.05	8.00	8.30
23	7.65	7.30	6.90	7.35	8.90	11.60	11.40	9.25	7.85	7.00	8.00	8.30
24	7.65	7.30	6.90	7.35	9.05	11.65	11.30	9.10	7.85	7.00	8.00	8.35
25	7.60	7.25	6.90	7.35	9.30	11.85	11.20	9.00	7.80	7.05	7.95	8.35
26	7.60	7.25	6.85	7.40	9.70	11.75	11.05	8.90	7.80	7.10	7.95	8.40
27	7.65	7.30	6.85	7.40	9.90	11.70	11.00	8.80	7.80	7.10	7.90	8.40
28	7.70	7.30	6.80	7.45	10.00	11.60	10.95	8.75	7.75	7.05	7.85	8.40
29	7.75	.....	6.80	7.40	10.00	11.55	11.00	8.70	7.75	7.05	7.85	8.45
30	7.75	.....	6.80	7.40	10.00	11.60	11.00	8.60	7.75	7.00	7.90	8.45
31	7.80	.....	6.85	.....	10.05	.....	11.00	8.50	.....	7.00	.....	8.50

NACHES RIVER AT NORTH YAKIMA, WASHINGTON.

This river has its source on the eastern slope of the Cascade Mountains in Yakima County, Washington. It flows in a general southeasterly direction, entering Yakima River a short distance above the town of North Yakima. Irrigation is practiced in the narrow valley along the lower course of the river, but its waters are of greater value for the irrigation of lands west of North Yakima. The river has considerable fall, and the water can be easily diverted by means of comparatively short canals. On this account it is of more value for irrigation purposes than Yakima River, which has less fall. The original station was established August 14, 1893, but was abandoned in 1897. It was reestablished February 1, 1898, and is now located near the Northern Pacific railway bridge at the mouth of the river. Owing to the fact that the wire gage was removed a number of times, an inclined rod was established June 20, 1899, with its zero 1.64 feet below the datum of the old gage; consequently, all heights recorded previous to June 20 should be increased by this amount to make them agree with those recorded since that date. The bench mark is the top

of the north end of the east sill of clearance post, about 150 feet north of the railroad bridge, and is at an elevation of 25.406 feet above datum of new gage. The bed of the river is rocky and is not liable to change at ordinary stages, but during the excessive floods to which this stream is subject the section is liable to great change. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 355; 1898, Twentieth Annual Report, Part IV, page 503. The following discharge measurements were made by Sydney Arnold in 1899:

May 4, gage height, 5.35 feet; discharge, 1,847 second-feet.
May 12, gage height, 6.85 feet; discharge, 5,434 second-feet.
May 26, gage height, 7.10 feet; discharge, 6,753 second-feet.
July 27, gage height, 7.25 feet; discharge, 2,856 second-feet.
August 16, gage height, 6.35 feet; discharge, 1,357 second-feet.
September 20, gage height, 5.70 feet; discharge, 588 second-feet.

Daily gage height, in feet, of Naches River at North Yakima, Washington, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	5.50	4.80	4.60	5.40	6.80	8.50	7.10	6.00	.....	5.90	8.40
2	4.70	5.30	4.80	.....	5.40	6.90	.....	7.00	6.00	5.80	5.90	8.20
3	4.70	4.90	4.70	4.60	5.40	6.90	8.50	6.90	.....	5.70	5.80	.....
4	4.50	4.80	4.70	4.80	5.40	.....	8.50	6.80	6.00	5.70	5.80	7.70
5	4.40	.....	.....	4.90	5.50	6.90	8.40	6.80	6.00	5.60	.....	7.50
6	4.40	4.70	4.70	4.90	5.80	7.00	8.40	.....	5.90	5.60	5.80	7.30
7	4.30	4.70	4.70	5.00	.....	7.00	8.30	6.80	5.90	5.60	5.90	7.20
8	.....	4.80	4.70	5.10	6.40	7.10	8.30	6.70	5.80	.....	6.10	7.10
9	4.30	5.10	4.60	.....	6.80	7.10	.....	6.60	5.80	5.60	6.20	6.90
10	4.30	5.20	4.60	5.50	7.20	7.00	8.30	6.60	.....	5.60	6.40	.....
11	4.20	5.20	4.60	5.50	7.20	.....	8.30	6.60	5.80	5.60	6.50	6.70
12	4.20	.....	.....	5.70	7.20	.....	8.30	6.60	5.80	5.60	.....	6.60
13	4.10	5.10	4.50	5.70	6.80	.....	8.40	.....	5.80	5.50	6.50	6.60
14	4.10	5.00	4.50	5.50	.....	7.86	8.40	6.50	5.70	5.50	6.50	6.60
15	.....	5.00	4.40	5.50	6.50	.....	8.40	6.50	5.70	.....	7.20	6.50
16	4.30	5.00	4.40	.....	6.40	.....	.....	6.40	5.70	5.50	7.20	6.50
17	4.30	5.00	4.40	5.50	6.40	.....	8.40	6.40	.....	5.50	7.10	.....
18	4.40	5.10	4.40	5.40	6.30	.....	8.30	6.40	5.70	5.60	6.90	6.30
19	4.40	.....	.....	5.30	6.20	.....	8.20	6.30	5.70	5.80	.....	6.30
20	4.50	5.00	4.40	5.30	6.20	a8.85	8.00	.....	5.60	6.40	8.10	6.20
21	5.80	5.00	4.40	5.20	.....	8.80	7.80	6.30	5.60	6.30	8.00	6.20
22	.....	5.10	4.40	5.20	6.40	8.70	7.50	6.20	5.60	.....	7.60	7.00
23	6.30	5.10	4.40	.....	6.40	8.70	.....	6.20	5.60	6.00	7.20	7.40
24	6.10	5.00	4.40	5.20	6.50	8.70	7.30	6.20	.....	6.00	7.00	.....
25	5.80	5.00	4.40	5.30	6.50	.....	7.30	6.10	5.60	5.90	7.00	8.30
26	5.80	.....	.....	5.30	6.60	8.70	7.20	6.10	5.60	5.90	.....	8.20
27	5.70	4.90	4.40	5.40	6.60	8.60	7.20	.....	5.60	6.00	7.80	8.00
28	5.70	4.80	4.40	5.40	.....	8.60	7.30	6.10	5.60	6.20	9.00	7.80
29	.....	.....	4.50	5.50	6.60	8.50	7.40	6.10	5.70	.....	8.90	7.60
30	5.70	.....	4.50	.....	6.70	8.50	7.20	6.10	5.80	6.00	8.60	7.40
31	5.60	.....	4.60	.....	6.80	.....	.....	6.00	.....	6.00	.....	.....

a New gage, datum 1.64 lower than old gage.

YAKIMA RIVER AT UNION GAP, WASHINGTON.

This river has its source in Keechelus Lake, on the eastern slope of the Cascade Mountains, in Kittitas County, Washington. In a short distance it receives the waters of Kachess Lake, and 2½ miles above Cle Elum it receives the outlet of the last of the three large headwater lakes. The valley of Yakima River is comparatively narrow until it widens out in the vicinity of Ellensburg, where considerable irrigation is practiced. At the lower end of this valley it enters a canyon 20

miles long, and then flows into Selah Valley, which is only 4 miles in length. At the lower end of this opening the river passes through a narrow gap to enter Yakima Valley. This section is the most extensively irrigated area in Washington, and is served principally by canals from Naches River. Seven miles below North Yakima the river passes through what is known as Union Gap, and thence enters its lower valley, which extends to Kiona. Yakima River enters Columbia River 23 miles below this point and just above the town of Pasco. The gaging station, established August 14, 1893, is located at Union Gap, 6 miles below North Yakima, Washington, and 1,000 feet below the highway bridge. It is about 3 miles above the head gate of the Sunnyside canal. The gage rod is inclined and is attached to a willow stump and posts set in the ground. The bench mark is the highest point of a large rock mound 25 feet north of the gage and 10 feet east of the fence, and is at an elevation of 17.52 feet above gage datum. The equipment consists of cable, car, and tagged wire. The station is of value in showing the amount of water available for the extensive irrigable lands below. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 358; 1897, Nineteenth Annual Report, Part IV, page 479; 1898, Twentieth Annual Report, Part IV, page 500. The following measurements of discharge were made by Sydney Arnold in 1899:

May 8, gage height, 8.03 feet; discharge, 8,500 second-feet.
August 18, gage height, 6 feet; discharge, 3,777 second-feet.
September 16, gage height, 5 feet; discharge, 1,730 second-feet.
October 6, gage height, 4.77 feet; discharge, 1,479 second-feet.

Daily gage height, in feet, of Yakima River at Union Gap, Washington, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.00	7.20	6.40	5.80	7.00	8.80	8.40	6.70	5.50	4.90	5.50	8.50
2	6.70	6.90	6.40	5.90	7.10	8.90	8.30	6.60	5.50	4.90	5.40	8.20
3	6.40	6.60	6.30	5.60	7.10	8.90	8.30	6.60	5.50	4.90	5.40	8.00
4	6.00	6.30	6.30	5.60	6.70	9.50	8.20	6.50	5.40	4.80	5.50	7.80
5	5.90	6.30	6.20	6.10	7.00	9.80	8.20	6.50	5.40	4.80	5.40	7.40
6	5.60	6.30	6.20	6.10	7.20	9.50	8.10	6.50	5.40	4.80	5.40	7.00
7	5.30	6.30	6.10	6.20	7.50	9.00	8.10	6.40	5.30	4.70	5.40	6.80
8	5.30	6.30	6.10	6.30	8.30	8.70	8.10	6.30	5.30	4.70	5.50	6.70
9	5.30	6.30	6.00	6.60	8.70	8.80	8.00	6.20	5.30	4.70	5.70	6.60
10	5.30	6.20	6.00	6.80	9.30	9.10	8.00	6.10	5.20	4.80	5.70	6.60
11	5.20	6.20	6.00	6.80	9.20	9.40	8.00	6.10	5.20	4.70	5.80	6.50
12	5.20	6.30	5.90	6.70	9.00	9.80	7.90	6.10	5.20	4.70	5.80	6.40
13	5.20	6.30	5.90	7.40	8.80	10.10	7.90	6.00	5.10	4.70	6.00	6.30
14	5.20	6.50	5.90	7.20	8.70	10.10	8.00	6.00	5.10	4.70	6.20	6.20
15	5.20	6.80	5.80	7.10	8.60	9.90	8.00	6.00	5.10	4.70	6.30	6.10
16	5.30	7.00	5.80	7.00	8.40	9.80	7.90	6.00	5.00	4.70	6.40	6.00
17	5.60	7.30	5.70	6.80	8.20	9.80	7.85	6.00	5.00	4.80	6.40	5.90
18	5.80	7.60	5.70	6.60	8.10	9.80	7.80	6.00	5.00	4.80	6.50	5.70
19	6.10	7.70	5.60	6.40	7.90	9.70	7.80	5.90	5.00	5.00	6.80	5.60
20	6.30	7.90	5.70	6.30	7.70	9.60	7.60	5.90	5.00	5.60	7.60	5.40
21	7.40	7.60	5.60	6.30	7.70	9.50	7.50	5.90	5.00	5.80	8.00	5.40
22	8.00	7.30	5.70	6.20	7.60	9.50	7.50	5.80	5.00	5.70	7.90	5.30
23	8.50	7.10	5.60	6.40	7.70	9.40	7.50	5.80	5.00	5.60	7.60	6.20
24	8.00	6.90	5.60	6.50	8.90	9.10	7.50	5.80	5.00	5.50	7.40	7.00
25	7.70	6.70	5.60	6.70	9.40	9.00	7.50	5.70	5.00	5.50	7.20	9.00
26	8.40	6.60	5.50	6.80	9.40	8.90	7.30	5.70	4.90	5.50	7.00	9.50
27	8.60	6.60	5.50	7.00	9.10	8.70	7.10	5.70	4.90	5.50	7.00	9.20
28	8.40	6.50	5.50	7.10	9.00	8.60	7.05	5.60	4.90	5.60	8.00	8.90
29	8.00	.....	5.60	7.00	8.90	8.40	6.90	5.60	4.90	5.60	9.00	8.10
30	7.80	.....	5.70	7.00	8.90	8.50	6.80	5.60	4.90	5.60	8.70	7.70
31	7.50	.....	5.80	.....	8.80	.....	6.70	5.50	.....	5.50	.....	7.70

YAKIMA RIVER AT KIONA, WASHINGTON.

'his station is located on the lower course of the river, at the point ere it bends northerly, sweeping around a point of hill to enter umbia River 23 miles below. The station, established August 20, 5, is located at the highway bridge at Kiona. The length of the e gage is 27.21 feet. The channel of the river is straight for some tance above and below. The banks are of medium height and the bed omposed of firm gravel. The bridge crosses the river with one span, l the section is an ideal one for discharge measurements. The results measurements may be found as follows: 1896, Eighteenth Annual port, Part IV, page 359; 1897, Nineteenth Annual Report, Part IV, ge 484; 1898, Twentieth Annual Report, Part IV, page 502. The fol- ing discharge measurements were made by Sydney Arnold in 1899:

July 18, gage height, 9.65 feet; discharge, 11,180 second-feet.
August 10, gage height, 6.16 feet; discharge, 3,482 second-feet.
September 7, gage height, 5.31 feet; discharge, 2,107 second-feet.
October 18, gage height, 4.42 feet; discharge, 1,244 second-feet.

Daily gage height, in feet, of Yakima River at Kiona, Washington, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.00	8.00	6.83	5.72	7.45	9.65	9.35	7.15	5.25	4.58	5.50	9.76
2	7.85	7.55	6.75	5.78	7.40	9.60	9.20	7.03	5.22	4.57	5.45	10.35
3	7.80	6.80	6.50	5.90	7.25	9.70	9.30	6.90	5.18	4.60	5.38	10.57
4	7.20	6.38	6.50	5.98	7.05	10.20	9.60	6.63	5.18	4.70	5.30	9.75
5	6.80	6.20	6.50	6.05	7.00	11.20	10.00	6.50	5.20	4.68	5.28	9.16
6	5.45	6.10	6.40	6.17	7.30	11.00	9.85	6.35	5.28	4.60	5.25	8.63
7	5.25	6.09	6.40	6.32	7.80	10.45	9.60	6.25	5.30	4.58	5.20	8.12
8	5.35	6.09	6.30	6.40	8.30	10.15	9.45	6.15	5.26	4.52	5.10	.....
9	5.40	6.15	6.35	6.50	.....	9.80	9.35	6.15	5.21	4.50	5.18	7.60
10	5.50	6.26	6.40	6.75	.....	9.90	9.38	6.15	.....	4.48	5.40	7.55
11	5.56	6.95	6.25	7.13	10.35	10.65	9.45	6.15	5.12	4.52	5.65	7.40
12	5.60	6.95	6.10	7.13	10.43	11.10	9.30	6.18	5.05	4.50	5.72	7.28
13	5.54	6.80	6.08	7.90	10.41	11.35	9.18	6.08	4.95	4.48	5.85	6.94
14	5.50	6.56	6.05	8.05	9.90	11.20	9.50	6.03	4.98	4.50	5.95	6.86
15	5.45	6.61	5.90	7.85	9.35	10.70	9.40	6.00	5.03	4.52	6.03	6.71
16	5.45	7.10	5.85	7.68	8.97	10.43	9.55	6.04	5.04	4.48	6.62	6.45
17	5.43	7.73	5.85	7.53	8.75	10.45	9.60	6.10	4.98	4.42	6.79	6.32
18	5.70	8.70	5.73	7.45	.....	10.80	9.60	6.08	4.95	4.48	6.96	6.20
19	6.22	9.23	5.60	7.38	8.40	11.25	9.33	6.00	4.92	4.80	7.25	6.05
20	6.40	8.50	5.60	.....	8.20	11.45	9.10	5.90	4.87	5.05	7.92	5.97
21	6.85	8.48	5.62	7.10	8.15	11.35	8.85	5.78	4.85	5.50	8.40	5.83
22	8.45	8.15	5.63	7.20	8.20	11.10	8.65	5.75	4.78	5.60	8.98	6.22
23	9.55	7.80	5.65	7.30	8.60	10.65	8.18	5.72	4.74	5.62	8.42	7.34
24	9.30	7.50	5.65	7.10	9.15	10.85	7.90	5.70	4.70	5.56	7.85	8.65
25	8.87	7.35	5.65	7.00	10.10	10.20	7.58	5.55	4.67	5.45	7.45	9.78
26	8.80	7.20	5.65	7.10	10.50	10.40	7.38	5.48	4.63	5.47	7.18	10.69
27	9.30	7.05	5.60	7.40	10.55	10.35	7.25	5.50	4.58	5.38	6.98	10.88
28	9.30	6.90	5.60	7.65	10.45	10.15	7.20	5.50	4.58	5.43	7.95	10.50
29	8.95	.....	5.65	7.55	10.30	9.70	7.20	5.45	4.57	5.52	8.46	9.77
30	8.65	.....	5.68	7.45	10.10	9.50	7.20	5.38	4.58	5.56	9.05	9.20
31	8.25	.....	5.70	.....	9.90	.....	7.25	5.32	.....	5.50	.....	8.96

WALLAWALLA RIVER AT WHITMAN, WASHINGTON.

'he tributaries of this river drain the northern and western slopes the Blue Mountains in southeastern Washington. The general rse of the stream is westerly, entering Columbia River 2 miles ow the mouth of Snake River. The Blue Mountains attain eleva- is of over 2,000 feet above their foothills, and their slopes are

well timbered. Agriculture is practiced to a considerable extent on the foothill regions in the vicinity of Wallawalla, the crops being raised without irrigation. A number of canals divert water from the river below Whitman and from the lower course of its tributary, Touchet River. To determine the amount of water available for irrigation below, a gaging station was established at Whitman, 7 miles below Wallawalla, July 19, 1897. The gage consists of a horizontal timber fastened to two posts set in the ground and projecting out over the water surface. To this horizontal rod is attached a wire gage. The bench mark is a nail driven into the northwest corner of a barn 70 feet north of the gage and 1 foot above the sill, and is at an elevation of 11 feet above gage datum. The length of gage wire is 19.62 feet. The discharge measurements were to have been made from a bridge, which, however, has not yet been erected. The results of measurements may be found as follows: 1897, Nineteenth Annual Report, Part IV, page 492; 1898, Twentieth Annual Report, Part IV, page 512. There were no discharge measurements made at this point during 1899.

Daily gage height, in feet, of Wallawalla River at Whitman, Washington, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.60	2.45	3.00	3.05	3.30	3.85	2.30	1.45	1.85	1.75	2.10	3.95
2	2.45	2.25	3.05	3.05	3.25	4.00	2.25	1.45	1.85	1.75	2.10	4.55
3	2.30	2.20	2.95	3.15	3.15	3.95	2.15	1.45	1.85	1.75	2.10	3.96
4	2.20	2.20	2.90	3.30	3.10	3.95	2.10	1.45	1.90	1.75	2.10	3.50
5	2.20	2.20	2.85	3.40	3.20	3.75	2.15	1.45	2.05	1.80	2.10	3.35
6	2.20	2.20	2.80	3.30	3.30	3.35	2.05	1.40	1.95	1.80	2.10	3.05
7	2.20	2.20	2.85	3.40	3.35	3.30	2.00	1.40	1.90	1.80	2.10	3.05
8	2.20	2.20	3.10	3.60	3.80	3.15	2.00	1.40	1.95	1.80	2.10	2.90
9	2.20	2.95	3.10	4.15	4.30	3.25	1.95	1.50	1.95	1.80	2.10	2.80
10	2.20	4.20	3.05	4.05	4.50	3.40	1.90	1.55	1.90	1.80	2.10	2.80
11	1.90	3.65	3.00	4.10	4.35	3.95	1.90	1.50	1.95	1.85	2.10	3.00
12	1.95	3.25	2.95	4.50	4.05	3.85	1.90	1.50	1.90	1.90	2.10	3.00
13	1.95	3.30	2.85	4.50	3.90	3.50	1.80	1.50	1.95	1.90	2.10	2.85
14	1.95	3.85	2.75	4.05	3.65	3.35	1.80	1.60	1.95	1.90	2.10	2.80
15	2.15	4.60	2.75	3.95	3.50	3.30	1.70	1.70	1.95	1.90	2.10	2.80
16	2.70	4.40	2.75	4.40	3.40	3.30	1.60	1.65	1.90	1.90	2.15	2.80
17	3.50	4.35	2.75	4.10	3.45	3.30	1.60	1.65	1.85	2.30	2.15	2.80
18	3.45	4.30	2.75	3.85	3.40	3.25	1.60	1.65	1.90	2.20	2.25	2.70
19	3.45	4.45	2.80	3.65	3.25	3.20	1.50	1.65	1.85	2.35	2.70	2.60
20	3.55	4.30	2.95	3.60	3.20	3.15	1.55	1.65	1.85	2.60	2.75	2.55
21	5.00	4.10	3.00	3.75	3.20	3.00	1.50	1.70	1.80	2.40	2.65	2.60
22	5.50	3.60	3.00	3.95	3.50	2.85	1.60	1.90	1.85	2.35	2.55	2.85
23	4.00	3.25	3.00	3.75	3.85	2.75	1.55	1.90	1.85	2.30	2.50	3.10
24	3.30	3.30	3.00	3.70	4.35	2.65	1.55	1.85	1.80	2.25	2.45	3.50
25	3.20	3.10	3.00	3.75	4.55	2.65	1.55	1.85	1.80	2.30	2.30	3.35
26	3.10	2.90	3.00	3.75	4.30	2.65	1.55	1.85	1.80	2.30	2.35	3.20
27	3.00	2.80	3.00	3.70	4.10	2.55	1.55	1.95	1.75	2.25	2.35	3.15
28	2.95	2.85	3.00	3.45	4.05	2.45	1.55	1.95	1.75	2.20	2.90	3.00
29	2.85	.....	3.00	3.25	4.05	2.40	1.45	1.90	1.75	2.20	3.50	2.90
30	2.75	.....	3.00	3.35	3.75	2.35	1.45	1.90	1.75	2.20	3.80	2.80
31	2.65	.....	3.00	.....	3.65	.....	1.45	1.90	.....	2.15	.....	2.80

UMATILLA RIVER AT GIBBON, OREGON.

This river rises in the well-wooded country in northeastern Oregon and flows in a general westerly direction, entering Columbia River below the mouth of Wallawalla River. The country north of Umatilla is high and rolling. Agriculture is practiced here to a consider-

extent, cereals being the principal crops raised. A· number of ls divert water from the lower course of the stream to irrigate s on either side. Surveys have been made for diverting water in vicinity of Gibbon to irrigate the high country between Umatilla Wallawalla rivers. None of the canals have yet been completed, ever. The station at Gibbon, Oregon, was established July 22, ;, and is located one-half mile west of the railroad station. The is inclined and is fastened to a rock ledge by bolts soldered into s drilled into the rock. The bench mark is a cross in black paint he highest point of the rock to which the rod is fastened, and .40 feet above gage datum. The results of measurements may be ıd as follows: 1896, Eighteenth Annual Report, Part IV, page ; 1897, Nineteenth Annual Report, Part IV, page 493; 1898, ntieth Annual Report, Part IV, page 515. There were no meas-nents of discharge made at this point during 1899.

Daily gage height, in feet, of Umatilla River at Gibbon, Oregon, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.55	2.50	2.40	2.65	2.50	3.85	.90	1.05	1.00	1.00	1.60	3.20
2	1.45	2.20	2.50	2.70	2.50	3.80	.80	1.05	1.00	1.00	1.50	2.90
3	1.40	2.00	2.50	2.75	2.50	3.70	.75	.05	1.00	1.00	1.45	2.75
4	1.30	1.95	2.40	3.30	2.55	3.50	.65	1.05	1.10	1.00	1.45	2.60
5	1.30	1.80	2.25	3.30	3.05	3.10	1.65	1.00	1.20	1.00	1.45	2.40
6	1.25	1.75	2.20	3.30	3.80	3.00	1.60	1.00	1.10	1.00	1.40	2.30
7	1.25	2.00	2.40	3.50	4.40	3.00	.60	.95	1.10	1.00	1.40	2.20
8	1.15	2.70	2.75	3.70	4.40	3.20	1.60	.95	1.10	1.00	1.40	2.20
9	1.10	3.30	2.60	4.30	4.90	3.30	1.55	.95	1.05	1.00	1.40	2.20
0	1.00	3.30	2.30	4.30	4.60	3.50	.50	1.05	1.05	1.00	1.40	2.20
1	.95	2.90	2.30	4.10	4.40	3.20	.50	.05	1.00	1.00	1.40	2.20
2	.90	2.60	2.10	5.00	4.20	3.10	.45	1.00	1.00	1.00	1.40	2.25
3	.90	2.50	2.10	4.20	4.05	2.95	.45	.00	1.05	1.00	1.40	2.20
4	.90	2.80	2.10	3.60	3.50	3.10	.45	1.00	1.00	1.00	1.45	2.20
5	.90	3.45	2.15	3.60	3.20	3.00	.40	1.00	1.00	1.00	1.50	2.20
6	1.80	3.30	2.15	3.80	3.10	2.90	.35	1.00	1.00	1.20	1.50	2.20
7	2.50	3.40	2.20	3.40	3.05	2.90	.35	1.00	1.00	1.40	1.50	2.15
8	2.90	3.60	2.30	3.20	3.05	2.75	.35	1.00	1.00	1.40	1.90	2.15
9	2.70	3.90	2.60	3.05	3.00	2.70	.30	1.00	1.00	1.60	2.10	2.10
0	3.30	3.70	2.50	3.40	2.95	2.60	.30	1.05	1.00	1.50	2.10	2.10
1	4.50	3.20	2.50	3.40	3.00	2.50	1.30	1.05	1.00	1.50	2.00	2.10
2	4.00	2.80	2.40	3.45	3.80	2.45	.25	1.35	1.00	1.50	1.80	2.05
3	3.10	2.60	2.20	3.50	4.10	2.40	.20	.20	1.00	1.50	1.80	2.00
4	3.00	2.45	2.60	3.50	4.40	2.25	.20	1.10	1.00	1.60	1.70	2.00
5	2.80	2.40	2.70	3.60	4.30	2.20	1.20	1.10	1.00	1.65	1.70	2.10
6	3.50	2.20	2.60	3.30	4.00	2.10	1.15	1.05	1.00	1.70	1.70	2.20
7	3.30	2.10	2.50	3.20	3.80	2.00	1.15	1.05	1.00	1.70	2.40	2.20
8	3.10	2.40	2.50	3.00	3.80	1.95	1.10	1.05	1.00	1.75	2.70	2.15
9	3.00	.....	2.55	2.75	4.00	1.90	1.10	1.05	1.00	1.70	3.10	2.15
0	2.70	.....	2.50	2.60	4.00	1.90	1.10	1.00	1.00	1.65	3.15	2.15
1	2.60	.....	2.60	.....	3.90	.....	1.10	1.00	.....	1.60	.....	2.10

DESCHUTES RIVER AT MORO, OREGON.

his river drains a large area in central Oregon and flows in a gen-northerly direction, entering Columbia River about 15 miles east 'he Dalles, Oregon. The headwater tributaries have their source ıe snow-clad peaks of the Cascade Mountains. The plains region vhich they enter upon their appearance from the mountain canyons : a very porous lava formation, which has a tendency to regulate flow of the river. The rains and snows of the winter are absorbed

by the porous rocks, to be slowly discharged into the river later in the season. In the vicinity of the town of Lava the river is noted for its unchanging flow, the height not varying, on an average, more than 12 to 18 inches during the year, with a comparatively large discharge. The river is a surface stream until about due west of Prineville, when it gradually cuts down, and on its lower course is in a canyon about 1,000 feet in depth. The lower portion of the river is also subject to greater fluctuations in height than the upper part. The general character of the lower basin of Deschutes River is high and rolling and it is difficult to irrigate, except from the high tributaries. Crooked River is an important tributary of the Deschutes, entering it from the east. Considerable irrigation, principally for forage crops, is practiced in its basin above Prineville. The station on Deschutes River, established October 19, 1897, is located at Moro, 3 miles above what is known as the "free bridge" and 16 miles east of The Dalles, Oregon. The rod is inclined. The bench mark is the head of a nail in a large alder tree, to which the rod is spiked, and is at an elevation of 8.41 feet above gage datum. Discharge measurements are taken at the iron bridge 3 miles below. The section here is poor, owing to its rocky cross section. The current is quite swift. The results of measurements may be found as follows: 1897, Nineteenth Annual Report, Part IV, page 97; 1898, Twentieth Annual Report, Part IV, page 516. One measurement of discharge was made in 1899 by Sydney Arnold, on June 10, when, at a gage height of 3.80 feet, a discharge of 10,772 second-feet was found.

Daily gage height, in feet, of Deschutes River at Moro, Oregon, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.70	2.50	5.50	2.70	3.50	4.00	3.30	2.50	2.30	1.90	2.30	3.70
2	1.70	2.40	3.90	2.90	3.40	4.00	3.30	2.50	2.30	2.00	2.30	3.60
3	1.60	2.20	3.30	2.90	3.30	4.00	3.40	2.50	2.30	2.00	2.30	3.50
4	1.60	1.90	3.00	3.00	3.10	3.90	3.40	2.40	2.40	2.00	2.30	3.40
5	1.50	1.70	2.80	3.30	3.10	3.80	3.30	2.40	2.50	1.90	2.30	3.40
6	1.40	1.60	2.70	3.60	3.20	3.80	3.30	2.40	2.50	1.90	2.40	3.40
7	1.40	1.50	2.70	3.70	3.30	3.70	3.30	2.40	2.40	1.90	2.40	3.30
8	1.30	1.40	2.60	3.80	3.70	3.70	3.20	2.40	2.40	1.90	2.40	3.20
9	1.30	3.60	2.60	3.90	4.10	3.60	3.20	2.40	2.40	2.00	2.40	3.20
10	1.20	5.00	2.50	4.10	4.30	3.70	3.20	2.30	2.30	2.00	2.40	3.10
11	1.20	4.00	2.50	4.30	4.30	3.70	3.30	2.30	2.30	2.00	2.30	3.20
12	1.30	3.60	2.60	4.60	4.40	3.80	3.30	2.30	2.30	2.00	2.30	3.30
13	1.30	3.00	2.50	4.70	4.40	3.90	3.30	2.30	2.30	2.10	2.30	3.60
14	1.20	2.80	2.50	4.90	4.20	3.90	3.20	2.20	2.20	2.10	2.30	4.10
15	1.30	2.60	2.40	4.60	4.00	3.80	3.20	2.20	2.20	2.10	2.30	4.10
16	2.90	2.50	2.40	4.30	3.90	3.80	3.10	2.20	2.20	2.10	2.30	3.90
17	2.70	2.50	2.30	4.10	3.80	3.70	3.10	2.20	2.20	2.10	2.30	3.70
18	3.40	2.80	2.30	3.90	3.60	3.80	3.10	2.10	2.20	2.20	2.20	3.60
19	3.20	2.80	2.50	3.70	3.40	3.90	3.00	2.20	2.10	2.50	2.20	3.60
20	3.40	2.90	2.50	3.50	3.40	3.90	3.00	2.10	2.10	3.10	2.20	3.70
21	3.70	2.80	2.40	3.80	3.30	3.80	2.90	2.10	2.10	2.50	2.20	3.90
22	4.10	2.70	2.40	4.00	3.30	3.70	2.80	2.20	2.10	2.30	2.20	3.80
23	3.60	2.70	2.50	4.10	3.40	3.70	2.80	2.40	2.10	2.30	2.20	3.70
24	3.10	2.60	2.50	4.10	3.50	3.60	2.70	2.40	2.00	2.30	2.20	3.60
25	2.80	2.60	2.80	4.00	3.60	3.60	2.70	2.40	2.00	2.30	2.20	3.60
26	2.70	2.50	3.50	3.90	3.70	3.50	2.70	2.50	2.00	2.40	2.30	3.50
27	2.60	2.40	3.30	3.80	3.80	3.50	2.60	2.50	2.00	2.40	3.70	3.40
28	2.40	2.50	2.90	3.70	3.90	3.50	2.60	2.50	1.90	2.40	4.10	3.30
29	2.20	.....	2.90	3.70	3.90	3.40	2.60	2.40	1.90	2.40	4.10	3.20
30	2.30	.....	2.80	3.60	3.90	3.40	2.60	2.40	1.90	2.40	4.10	3.20
31	2.70	.....	2.70	.....	4.00	.....	2.50	2.40	.....	2.40	.....	3.10

A survey of a portion of Deschutes River, from Pringle Falls above the East Fork down to and including the country around Prineville, on Crooked River, and below Warmspring, was made during May and June, 1899, by Mr. G. F. Allardt, civil engineer for the Oregon Irrigation Company. Sufficient information was obtained to locate the general routes of the main irrigating canals and to determine the limits of the country that could be watered. The following details are taken from the report by Mr. Allardt:

Measurements of the river were made on May 27, 1899, at Sizemore bridge, about 1 mile above Emigrant Ford, giving a flow of 3,014 second-feet. At the time of measurement the river was somewhat above its ordinary stage and was 380 feet wide, with an average depth of about 3 feet and a mean velocity of nearly 3 feet per second. At its lowest stage the discharge of the river was estimated, from marks pointed out by the oldest settlers, to amount to 1,740 second-feet. It is stated that the difference between the high- and low-water marks does not exceed 2 feet in the wider portions of the river.

The low banks of the river make possible the diversion of water into canals by means of open cuts from the river channel at points a short distance above the various falls or rapids, thus dispensing with dams. The slight fluctuations in surface level reduce the cost of headworks to a minimum, and as the river never freezes it is unnecessary to adopt precautionary measures against ice.

Five principal canals were surveyed, leading out in succession from the east or right-hand side of the river. The first of these heads at Pringle Falls and has a length of 30 miles; the next heads at Benham Falls, 18 miles below, and has a length of 15 miles; the third heads at Lava Island, 4 miles below, and has a length of 34 miles; the fourth heads at Emigrant Ford, 5 miles below, and has a length of 33 miles; the fifth, or North canal, heads 20 miles below, and has a length of 47 miles, extending to Trout Creek. The following table gives the principal facts concerning the acreage irrigable and the altitude of the lands. Of the total acreage about one-fourth, or 92,000 acres, is timbered:

Proposed canals from Deschutes River.

Name.	Length.	Area irrigable.	Altitude.
	Miles.	*Acres.*	*Feet.*
Pringle Falls canal	30	36,000	4,100–4,300
Benham Falls canal	15	22,000	3,800–4,100
Lava Island canal	34	103,000	3,600–3,800
Emigrant Ford canal	33	168,000	2,900–3,600
North canal	47	58,000	2,400–2,900
Total	159	387,000	.....

The slope of the irrigable country from south to north is fairly uniform, averaging about 23 feet to the mile. The soil is mainly composed of volcanic ash or finely disintegrated lava, easily cultivated, and when wet of a dark or chocolate color. About one-fourth of the irrigable land is somewhat stony or broken by outcroppings of lava. The rainfall at Prineville averages about 9 inches per annum.

A large amount of power can be created by the use of the surplus waters of the river, as the total fall of the river is 1,360 feet between Pringle Falls and Crooked River. It is estimated that more than 50,000 effective horsepower can be produced by diverting the water by means of short flumes and without the construction of dams.

HOOD RIVER AT TUCKER, OREGON.

This river rises at the base of Mount Hood, which has an elev of 11,225 feet and is covered with snow throughout the year. upper part of its basin is mountainous and well wooded. The itself flows in a very narrow valley throughout its entire cours empties into Columbia River almost opposite White Salmon I which enters from the State of Washington. Hood River Vall called, is a level, elevated district, extending from the edge of th overlooking Columbia River southward for a distance of from 7 miles. The river in its 30-mile course has a heavy fall, so that diverting water from it can in a short distance attain consid elevation above the river. A number of canals divert water fron Fork and from the main Hood River, and irrigate the bench land of the town of Hoodriver. The chief products are berries and The gaging station, established October 20, 1897, is located at T 5 miles south of Hoodriver, Oregon. The rod of the wire g nailed to a wooden member of the bridge. The length of th wire is 33.85 feet. The bottom of the river is a rock ledge a sides are precipitous, thus insuring a stable cross section. Res measurements may be found as follows: 1897, Nineteenth A Report, Part IV, page 499; 1898, Twentieth Annual Report, Pa page 516. One measurement of discharge was made by Sydney A during 1899, on June 9, when at a gage height of 4.55 feet a dis of 2,548 second-feet was found.

Daily gage height, in feet, of Hood River at Tucker, Oregon, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	4.20	40	7.50	2.80	3.80	4.60	3.80	3.00	2.60	3.20	2.10
2	4.00	00	6.00	2.90	3.60	4.50	3.90	3.00	2.50	2.60	2.10
3	3.80	3.80	4.80	3.00	3.50	4.50	4.00	2.90	2.50	2.30	2.00
4	3.60	3.50	4.60	3.50	3.50	4.50	4.10	2.90	2.70	2.30	2.20
5	3.50	3.60	4.20	3.40	3.40	4.70	4.00	2.90	2.50	2.20	2.20
6	3.30	3.20	4.00	3.30	3.60	4.10	4.00	2.90	2.60	2.20	2.20
7	3.00	3.30	4.00	3.20	3.50	4.10	3.90	2.90	2.40	2.10	2.70
8	2.80	4.10	3.80	3.20	3.70	4.50	3.80	2.80	2.40	2.10	2.60
9	2.60	6.15	3.80	3.50	4.20	4.70	3.80	2.80	2.40	2.10	2.70
10	2.40	6.50	3.70	3.50	4.40	4.50	3.80	3.60	2.30	2.10	2.80
11	2.30	5.50	3.60	4.50	4.90	5.50	3.80	3.00	2.30	2.10	2.80
12	2.20	4.80	3.50	6.60	4.40	5.20	3.80	2.80	2.40	2.10	2.80
13	2.10	4.60	3.50	5.50	4.30	5.00	3.90	2.70	2.40	2.00	2.70
14	2.00	4.40	3.30	4.50	3.90	4.50	4.00	2.60	2.40	1.90	2.70
15	4.00	5.50	3.70	4.20	3.60	4.50	4.10	2.60	2.30	1.70	2.60
16	6.30	4.80	3.20	4.50	3.60	4.40	4.10	2.70	2.30	1.80	2.70
17	6.20	4.50	3.00	4.50	3.60	4.60	4.00	2.70	2.30	2.00	2.70
18	6.10	50	3.00	4.00	3.60	4.80	4.00	2.60	2.30	2.60	2.80
19	5.80	40	3.00	4.00	3.60	5.00	3.90	2.60	2.30	5.10	5.40
20	7.15	4.30	3.00	3.90	3.50	4.60	3.90	2.60	2.30	4.00	4.50
21	11.00	4.20	3.00	3.90	3.50	4.20	3.50	2.60	2.30	3.60	4.40
22	7.50	4.00	3.00	3.90	3.60	4.20	3.40	4.00	2.20	3.00	4.00
23	6.50	3.90	2.90	5.30	3.70	20	3.20	2.90	2.10	2.70	3.80
24	5.30	3.70	2.90	5.45	3.90	20	3.20	2.70	2.10	2.60	3.50
25	4.90	3.60	2.80	6.00	4.00	4.40	3.20	2.70	2.10	2.50	3.20
26	5.80	3.50	2.70	5.45	4.00	20	3.20	2.80	2.10	2.50	3.30
27	4.50	4.20	2.70	5.50	4.00	4.20	3.20	3.30	2.20	2.40	6.00
28	4.20	5.65	2.70	5.30	4.40	3.90	3.30	2.80	2.20	2.30	5.80
29	4.10		2.70	5.35	4.40	3.90	4.00	2.70	2.20	2.30	7.20
30	4.10		2.80	3.90	4.40	3.90	3.40	2.60	2.60	2.20	6.60
31	4.80		2.80	.....	4.00		3.20	2.60	.....	2.20	.....

WHITE RIVER AT BUCKLEY, WASHINGTON.

This river has its source in the glaciers of Mount Rainier, in the Cascade Range in Washington, and flows in a general northwesterly direction, entering Puget Sound at Seattle. Its mountainous collecting area is densely forested, and owing to the great precipitation on the western slope of the Cascade Mountains the basin has a high runoff. On account of the great fall of the rivers on the western slope of the Cascade Mountains in Washington, there are a number of fine water powers. These have lately been under investigation. In order to determine the amount of power that could be developed on White River, a station was established by Sydney Arnold, April 22, 1899, at the new highway bridge, 500 feet above the Northern Pacific railway bridge, and one-half mile north of the town of Buckley, Washington. The location is in sec. 34, T. 20 N., R. 6 E. of the Willamette meridian. The rod of the wire gage is fastened to the guard rail of the highway bridge. The length of the wire rope is 20 feet. The elevation of the top of the guard rail at the pulley is 19.56 feet above gage datum. The bridge is a clear span of 180 feet, crossing the river a trifle obliquely. The channel is straight for some distance above and below the bridge, but the section is not a very good one, owing to the sudden fall a short distance below. About 300 feet above the bridge is a good section, with fine gravel bottom in calmer water, but in order to utilize it it would be necessary to erect a cable. An examination of the river channel for some distance above and below this point was made, but the present location is about the only one available for accurate results. The following measurements of discharge were made by Sydney Arnold in 1899:

Discharge measurements of White River at Buckley, Washington.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
June 5	3.15	3,825	August 23	2.50	2,065
June 21	3.37	3,971	September 13	1.78	1,216
July 25	2.37	2,321	September 27	1.55	1,015
August 8	2.05	1,618	October 9	1.45	993

Daily gage height, in feet, of White River at Buckley, Washington, for 1899.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	2.00	2.86	2.80	2.30	2.00	1.67	1.67
2	.....	1.85	3.05	3.07	2.17	1.93	1.45	1.60
3	.....	1.78	3.19	3.47	2.05	1.93	1.40	1.55
4	.....	1.75	3.44	3.30	2.10	1.90	1.40	1.65
5	.....	1.96	3.08	2.97	2.07	1.80	1.33	1.50
6	.....	2.13	3.00	2.93	2.03	1.75	1.33	1.45
7	.....	2.15	2.78	2.90	2.00	1.63	1.30	1.95
8	.....	2.78	2.82	3.00	2.05	1.63	1.75	1.75
9	.....	3.17	3.20	2.95	2.05	1.55	1.45	1.93
10	.....	2.88	3.81	3.05	2.08	1.55	1.45	1.93
11	.....	2.98	4.31	3.00	1.95	1.70	1.40	1.93
12	.....	2.70	3.83	3.13	1.85	1.85	1.40	1.80
13	.....	2.64	3.58	3.15	1.80	1.78	1.33	1.95
14	.....	2.64	3.15	3.20	2.33	1.65	1.20	2.50
15	.....	2.35	3.27	3.20	2.27	1.65	1.10	2.63
16	.....	2.28	3.65	3.33	2.13	1.60	3.10	2.63
17	.....	2.37	3.85	3.15	2.05	1.60	2.25	2.35
18	.....	2.56	3.95	2.95	2.05	1.53	1.95	3.40
19	.....	2.67	3.78	2.90	1.93	1.53	2.90	4.50
20	.....	2.62	3.56	2.75	1.93	1.57	2.45	3.85
21	.....	2.70	3.37	2.55	1.85	1.50	2.13	3.35
22	1.93	2.75	3.23	2.47	2.86	1.43	1.93	2.80
23	2.10	3.07	3.30	2.45	2.47	1.40	1.75	2.65
24	1.98	3.32	3.42	2.50	2.15	1.47	1.95	2.40
25	1.95	3.30	3.28	2.37	2.05	1.60	1.85	2.27
26	2.05	3.06	3.15	2.45	2.05	1.60	2.23	2.80
27	2.05	3.05	2.93	2.66	2.10	1.55	2.23	3.10
28	1.95	2.92	2.90	2.73	1.95	1.45	2.10	4.20
29	2.00	2.85	2.90	2.60	1.85	1.45	1.90	3.95
30	2.05	2.78	2.75	2.53	1.80	1.73	1.87	3.80
31	.....	2.66	.....	2.37	1.80	.....	1.75	.....

CEDAR RIVER AT VAUGHN BRIDGE, WASHINGTON.

This river is a tributary of White River and has its source western slope of the Cascade Mountains. Flowing in a general westerly direction, it enters White River a few miles above its r A study of its discharge has been made during several ye T. A. Noble, for the Seattle Power Company, as there are a n of fine water-power privileges along its course. The station first established at Clifford bridge, but was moved in July, 18 Vaughn bridge, 15 miles above, and about 3,000 feet below the of Cedar Lake. The drainage area at this point is 80 square mil order to reduce the gage heights to sea-level datum 990 feet sho added. The channel was changed during the high water of 18 1899, so that all readings at Vaughn bridge after October, 18 not absolutely reliable.

Daily gage height, in feet, of Cedar River at Vaughn bridge, Washington, for 1898.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	2.24	1.50	1.30	2.01	2.10	2.40	17.....	1.80	1.30	1.20	1.90	3.25	1.70
2....	2.20	1.50	1.30	2.10	2.62	2.35	18.....	1.80	1.30	1.20	1.80	3.31	1.73
3....	2.20	1.50	1.30	1.96	2.41	2.32	19.....	1.90	1.30	1.20	1.80	3.31	1.80
4....	2.20	1.50	1.40	1.84	2.60	2.30	20.....	1.90	1.30	1.30	1.72	3.20	2.30
5....	2.20	1.50	1.30	1.75	2.73	2.30	21.....	1.80	1.30	1.35	1.74	3.10	2.30
6....	2.20	1.50	1.30	1.70	2.80	2.22	22.....	1.70	1.30	1.60	1.74	3.20	1.92
7....	2.10	1.40	1.30	1.63	2.84	2.22	23.....	1.70	1.30	1.70	1.75	2.70	2.27
8....	2.10	1.40	1.30	1.58	2.75	1.99	24.....	1.70	1.30	1.60	1.70	2.57	2.93
9....	2.00	1.40	1.20	1.64	2.63	1.85	25.....	1.60	1.30	1.50	1.70	2.51	3.30
10....	2.00	1.40	1.20	1.69	2.40	1.80	26.....	1.60	1.30	1.60	1.70	2.31	3.70
11....	2.00	1.40	1.20	1.74	2.31	1.80	27.....	1.60	1.30	1.50	1.74	2.50	4.80
12....	1.90	1.40	1.20	1.65	2.30	1.74	28.....	1.60	1.30	1.60	1.85	2.35	5.40
13....	1.90	1.40	1.25	1.80	2.21	1.70	29.....	1.60	1.30	1.71	1.87	2.40	4.60
14....	1.90	1.40	1.20	1.90	2.06	1.70	30.....	1.50	1.30	1.95	1.80	2.43	3.50
15....	1.80	1.40	1.20	1.94	2.13	1.70	31.....	1.50	1.30	.....	2.00	.....	3.40
16....	1.80	1.40	1.20	1.94	2.25	1.70							

DUNGENESS RIVER AT DUNGENESS, WASHINGTON.

This river rises on the eastern slope of the Olympic Mountains and flows in a general northerly direction, entering the strait of Juan de Fuca at the town of Dungeness, Washington, about 15 miles east of Port Angeles. Its mountainous drainage basin is highly picturesque and very heavily timbered. Although this section of the country receives a heavy precipitation, it occurs when least needed, and during the summer season recourse must be had to irrigation. The station originally established—July 5, 1897—was located 9 miles above the mouth of the river. July 29, 1898, it was moved to the bridge 8½ miles below. This bridge crosses the river diagonally, at an angle of about 15°. The length of the wire rope of the gage is 26.04 feet. The results of measurements may be found as follows: 1897, Nineteenth Annual Report, Part IV, page 504; 1898, Twentieth Annual Report, Part IV, page 518. The following measurements of discharge were made by W. J. Ware during 1899:

Discharge measurements of Dungeness River at Dungeness, Washington.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
January 31	4.00	440	May 30	4.10	536
February 22	3.80	443	July 5	4.55	627
March 29	2.95	228	August 31	3.35	223
April 28	3.25	253	September 16	3.25	205

Daily gage height, in feet, of Dungeness River at Dungeness, Washington, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.55	3.90	3.60	3.00	3.20	4.25	4.40	4.10	3.35	3.05	3.80	8.10
2	3.45	3.70	3.55	3.00	3.20	4.50	4.45	4.05	3.40	3.05	3.85	7.20
3	3.40	3.55	3.50	3.05	3.20	4.50	4.70	4.00	3.40	3.00	3.90	6.00
4	3.30	3.55	3.50	3.10	3.15	4.45	4.50	3.95	3.40	3.00	3.95	5.00
5	3.20	3.45	3.45	3.20	3.20	4.45	4.60	4.00	3.35	2.95	3.95	4.80
6	3.10	3.40	3.40	3.30	3.25	4.40	4.60	4.00	3.35	3.00	3.95	4.50
7	3.00	3.45	3.55	3.35	3.40	4.40	4.55	3.90	3.35	2.95	3.95	4.35
8	2.95	3.60	3.55	3.40	3.60	4.50	4.50	3.85	3.30	2.95	4.00	4.20
9	3.00	3.60	3.50	3.45	4.55	4.70	4.45	3.80	3.30	2.95	4.20	4.00
10	3.85	3.65	3.50	3.45	4.20	4.80	4.40	3.75	3.35	2.90	5.40	3.90
11	3.55	3.70	3.50	3.45	4.10	4.90	4.35	3.70	3.35	2.90	5.55	3.90
12	3.15	3.70	3.45	4.05	4.00	5.00	4.40	3.60	3.35	2.85	4.90	3.85
13	3.05	3.75	3.40	3.90	3.85	4.65	4.45	3.50	3.30	2.85	5.40	3.85
14	3.30	3.80	3.35	3.80	3.75	4.55	4.45	3.40	3.30	2.80	6.00	3.75
15	3.15	4.20	3.30	3.65	3.70	4.75	4.50	3.30	3.25	2.80	5.50	3.70
16	3.25	4.30	3.20	3.50	3.65	4.90	4.55	3.20	3.20	2.90	5.40	3.65
17	3.40	4.10	3.15	3.45	3.80	5.05	4.55	3.00	3.20	3.00	5.45	3.60
18	4.80	4.00	3.15	3.40	3.75	4.95	4.50	2.80	3.20	3.50	5.35	3.80
19	4.40	4.30	3.10	3.30	3.80	4.85	4.50	2.50	3.15	4.05	7.10	4.00
20	4.80	4.15	3.10	3.30	3.90	4.65	4.40	2.35	3.15	4.50	6.00	4.50
21	5.20	3.80	3.15	3.25	4.00	4.55	4.30	2.40	3.10	4.00	5.75	5.00
22	4.70	3.75	3.10	3.20	4.10	4.55	4.15	2.40	3.10	3.65	5.30	6.25
23	4.65	3.70	3.10	3.20	4.20	4.60	4.00	2.40	3.10	3.40	5.00	6.50
24	4.60	3.60	3.05	3.30	4.50	4.50	4.05	2.40	3.20	3.30	5.50	6.00
25	4.50	3.50	3.00	3.35	4.65	4.50	4.05	2.45	3.20	3.25	6.00	5.60
26	4.40	3.50	2.95	3.40	4.65	4.40	4.10	2.45	3.15	3.40	7.45	5.20
27	4.35	3.55	3.00	3.35	4.45	4.30	4.10	3.40	3.10	3.55	7.55	4.85
28	4.30	3.60	3.00	3.30	4.30	4.30	4.15	3.35	3.10	3.60	7.20	4.65
29	4.20	.....	3.00	3.25	4.20	4.25	4.15	3.30	3.05	3.80	7.20	4.50
30	4.10	.....	3.00	3.20	4.10	4.35	4.20	3.30	3.05	3.85	9.00	4.40
31	4.00	.....	3.00	.....	4.10	.....	4.25	3.35	.....	3.95	.....	4.40

ELWHA RIVER AT MCDONALD, WASHINGTON.

This river rises in the Olympic Mountains and flows northerly, entering the strait of Juan de Fuca. Its upper basin is very heavily wooded, and is almost inaccessible on account of its rugged character and the dense undergrowth that covers the mountain slopes. In the lower course of the river a number of falls occur where power could be advantageously developed, and within the last few years surveys having this object in view have been made.

Morse River drains a small area east of Elwha River. It flows northward, entering the strait of Juan de Fuca 4 miles east of Port Angeles. Plans contemplating the use of this stream for the city supply of Port Angeles are under consideration. The river also furnishes opportunities for the development of water power. Three measurements of the discharge of the river were made by W. J. Ware in 1899. The first, on June 3, showed a discharge of 242 second-feet; the second, on July 6, showed a discharge of 189 second-feet; the third, on September 15, gave a discharge of 62 second-feet.

Indian Creek is a tributary of Elwha River, entering it from the west about one-fourth of a mile below the gaging station. On June 16 it was discharging 45 second-feet.

Little River is another tributary of Elwha River and enters it from the east side about one-fourth of a mile below the bridge at which the gaging station on the main stream is located. On June 16 it was carrying 84 second-feet.

lam River drains an area in northwest Washington, entering the of Juan de Fuca at the town of East Clallam. On March 22, its discharge, as measured by W. J. Ware, was found to be 45 -feet.

gaging station on Elwha River, established October 8, 1897, is l 9 miles southwest of Port Angeles, at the new county bridge llam County, Washington. The horizontal rod of the wire gage ened to the guard rail at the north side of the bridge. The of the gage wire is 49.26 feet. The bench mark is the top edge top side rail on the north side of the bridge at the third upright om the east end, and is at an elevation of 41.34 feet above datum. nannel is straight for some distance above and below the station. nanks are high and rocky and will not overflow. The bed of the ı is rocky. The results of measurements may be found as fol- 1897, Nineteenth Annual Report, Part IV, page 506; 1898, ieth Annual Report, Part IV, page 521. The following discharge rements were made by W. J. Ware during 1899:

January 27, gage height, 3.29 feet; discharge, 1,978 second-feet.
March 18, gage height, 2.20 feet; discharge, 674 second feet.
March 31, gage height, 1.75 feet; discharge, 547 second-feet.
April 24, gage height, 2.15 feet; discharge, 727 second-feet.
June 16, gage height, 4.10 feet; discharge, 2,420 second-feet.
July 31, gage height, 3.40 feet; discharge, 1,644 second-feet.
August 30, gage height, 1.95 feet; discharge, 586 second-feet.

aily gage height, in feet, of Elwha River at McDonald, Washington, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	2.85	3.00	2.48	1.80	2.00	3.79	3.40	3.16	2.15	2.01	2.09	6.30
.....	2.84	2.70	2.44	1.74	1.93	3.50	3.70	3.15	2.16	1.60	1.95	5.58
.....	2.70	2.62	2.26	1.63	1.91	3.95	3.90	3.15	1.96	1.58	2.60	4.80
.....	2.48	2.51	2.20	1.70	1.90	3.96	4.10	3.00	1.91	1.57	2.56	4.71
.....	2.40	2.47	2.18	1.69	2.04	3.55	4.01	2.90	1.94	1.55	2.09	4.35
.....	2.24	2.34	2.22	1.72	2.06	3.40	3.90	2.90	1.91	1.55	2.03	3.96
.....	2.19	2.32	2.65	1.86	2.24	3.33	3.75	2.85	1.82	1.54	2.96	3.92
.....	2.10	2.74	2.85	1.90	3.13	3.72	3.60	2.76	1.76	1.80	2.66	3.66
.....	2.20	3.13	2.46	1.84	3.43	3.85	3.66	2.97	1.72	1.69	4.78	3.62
.....	2.85	2.67	2.42	2.20	3.42	4.46	3.60	3.30	1.69	1.65	4.73	3.54
.....	2.40	2.59	2.34	3.33	3.31	4.52	3.40	2.75	2.00	1.61	5.11	3.80
.....	2.28	2.79	2.27	3.58	3.28	3.85	3.60	2.68	2.02	1.50	3.88	3.53
.....	2.34	2.87	2.19	3.42	3.19	3.85	3.92	2.60	1.98	1.35	5.58	3.20
.....	2.68	3.29	2.16	2.60	3.02	3.65	4.02	2.65	1.95	1.30	5.48	3.19
.....	2.40	4.94	1.99	2.48	2.95	3.80	4.15	2.42	1.77	1.31	4.64	2.99
.....	2.48	5.00	1.95	2.34	2.90	4.01	4.10	2.60	1.74	1.96	3.98	2.95
.....	3.45	3.65	2.00	2.30	2.40	4.46	4.05	2.70	1.72	1.68	3.65	2.96
.....	4.52	3.52	2.20	2.25	2.39	4.15	4.10	2.55	1.72	1.80	6.46	2.70
.....	3.90	3.46	1.91	2.14	2.45	4.02	3.95	2.49	1.66	3.23	8.83	2.61
.....	4.93	3.25	1.85	2.12	2.47	3.77	3.73	2.40	1.65	3.33	5.65	3.16
.....	5.00	2.92	1.90	2.08	2.70	3.74	3.64	2.32	1.66	2.62	5.62	5.26
.....	4.10	2.80	1.84	2.07	2.74	3.75	3.40	2.35	1.71	2.19	6.31	8.57
.....	3.80	2.99	1.83	2.05	2.78	3.80	3.33	2.37	1.66	2.07	5.46	6.45
.....	3.45	2.80	1.76	2.10	3.45	3.94	3.42	2.20	1.78	2.00	5.22	5.10
.....	3.72	2.69	1.74	2.05	3.54	3.88	3.32	2.20	1.82	1.98	4.87	4.98
.....	3.38	2.85	1.62	2.00	3.64	3.75	3.50	2.20	1.80	2.05	8.09	4.50
.....	3.29	2.58	1.63	1.97	3.71	3.54	3.56	2.04	1.79	3.35	7.80	4.19
.....	3.22	2.55	1.61	2.05	3.29	3.48	3.64	2.01	1.63	3.36	8.38	3.86
.....	3.10	.....	1.70	2.08	3.20	3.35	3.74	1.95	1.61	3.00	5.67	3.82
.....	2.97	.....	1.78	2.04	3.18	3.32	3.65	1.90	2.35	2.39	10.00	3.79
.....	3.30	.....	1.75	.....	3.25	.....	3.39	1.90	.....	2.10	.....	3.69

CALOWA RIVER AT FORKS, WASHINGTON.

This river has its source on the western slopes of the Olympic Mountains, and flows in a general westerly and southerly direction, uniting with the Solduck and Bogachiel rivers, to form Quillayute River, which enters the Pacific Ocean at Lapush, Washington. The gaging station, established November 12, 1897, is located at the county highway bridge in the southwestern part of Clallam County, near Forks, Washington, and is reached by steamer from Port Angeles to Clallam Bay, and thence overland 30 miles by wagon. The horizontal rod of the wire gage is nailed to the railing of the wagon bridge. The banks are high and rocky, and do not overflow. The results of measurements may be found as follows: 1897 and 1898, Twentieth Annual Report, Part IV, page 522. Three measurements of discharge were made by W. J. Ware during 1899. The first, on March 24, at a gage height of 1.65 feet, gave a discharge of 584 second-feet; the second, on June 23, at a gage height of 0.85 foot, showed a discharge of 265 second-feet; the third measurement, on September 12, at a gage height of 0.20 foot, showed a discharge of 81 second-feet.

Daily gage height, in feet, of Calowa River at Forks, Washington, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.85	2.25	5.20	1.40	2.20	1.85	.60	0.00	-.20	.00	1.45	8.25
2	2.00	1.85	3.85	1.05	2.25	1.85	.60	0.05	-.25	.00	1.20	5.20
3	2.70	1.80	3.65	2.45	2.25	1.80	.60	0.00	-.20	.00	2.85	4.40
4	2.85	1.65	3.45	2.25	2.45	1.65	.60	0.00	-.05	.05	2.20	4.65
5	2.80	1.65	3.60	2.20	2.20	1.60	.60	-.05	.00	.20	2.05	4.85
6	2.60	1.85	3.05	2.20	2.20	1.45	.45	-.20	-.05	.05	2.20	4.85
7	2.20	2.00	5.60	2.05	2.20	1.40	.45	.05	-.25	-.05	2.40	4.80
8	2.05	2.45	5.00	2.05	3.00	1.25	.45	.00	-.25	.00	2.60	4.65
9	2.85	3.65	5.20	2.65	2.25	1.25	.45	.00	-.20	.05	5.05	4.45
10	7.45	3.00	5.00	2.05	3.00	1.45	.40	.05	-.20	.05	4.85	4.40
11	5.25	3.20	3.85	7.60	2.85	1.65	.40	.20	-.25	.00	5.00	4.25
12	5.00	4.00	3.45	5.40	2.25	1.60	.25	.05	-.20	-.05	4.60	4.20
13	4.85	4.60	3.05	4.30	2.20	1.40	.20	.20	-.25	-.20	4.45	4.20
14	5.40	7.05	2.85	3.45	2.20	1.20	.20	.05	-.25	-.20	5.05	4.20
15	6.80	7.60	2.60	3.60	2.20	1.20	.25	.00	-.25	+.05	5.00	3.25
16	6.00	6.05	2.40	3.45	2.25	1.20	.25	.05	-.25	1.80	4.25	2.45
17	8.00	6.85	2.05	3.20	2.25	1.20	.20	.05	-.40	1.05	3.65	2.00
18	8.45	6.60	2.00	3.20	2.20	1.05	.20	.00	-.40	.80	11.40	2.40
19	9.00	6.00	1.85	3.40	2.20	1.00	.20	.00	-.40	3.85	8.20	2.25
20	10.80	4.00	1.85	2.80	2.20	.80	.25	-.05	-.45	4.45	8.25	4.25
21	8.00	3.80	1.80	2.45	2.05	.85	.20	-.15	-.60	2.65	8.45	7.85
22	6.80	3.20	1.80	2.40	2.05	.80	.20	-.05	-.60	2.05	8.05	14.00
23	5.00	3.05	1.85	2.20	2.00	.85	.05	.20	-.60	1.65	8.25	7.85
24	4.00	3.20	1.65	2.20	1.85	.85	.05	-.20	-.60	2.25	6.25	6.00
25	4.25	3.60	1.60	2.25	1.85	.85	.00	-.25	-.45	1.80	5.05	5.00
26	4.00	5.20	1.60	2.80	1.85	1.40	.00	-.25	-.40	1.60	6.45	4.45
27	3.60	5.00	1.45	2.60	2.25	1.00	.00	-.25	.45	4.20	7.25	4.40
28	3.00	5.60	1.45	2.20	2.05	.85	-.05	.25	-.65	3.80	6.65	4.40
29	2.85	.....	1.45	2.45	2.00	.80	-.05	-.25	-.20	-3.60	5.00	4.25
30	2.45	.....	1.45	2.00	1.85	.65	-.20	-.25	.25	2.20	13.00	4.25
31	2.40	.....	1.45	.....	1.85	.....	-.05	-.20	.....	1.85	.....	4.20

SOLDUCK RIVER AT QUILLAYUTE, WASHINGTON.

This river has its source on the high western slope of the Olympic Mountains, and drains the country immediately north of the Calowa, *joining* it, as noted above, to form Quillayute River. The drainage

asin is very heavily wooded, the greater portion of it being included ı the Olympic Forest Reserve. The station, established November 3, 1897, is located at the county highway bridge 9 miles northeast of apush, near Quillayute, Washington. The horizontal rod of the ire gage is fastened to the rail of the wagon bridge. The channel is traight for some distance above and below the station. The banks re high and rocky and do not overflow. The bed of the stream is omposed of rock and gravel and is not liable to change. The results f measurements for 1897 and 1898 may be found in the Twentieth Annual Report, Part IV, page 523. Three measurements of discharge vere made by W. J. Ware in 1899: The first, on March 24, at a gage neight of 3.15 feet, showed a discharge of 1,023 second-feet; the second, on June 23, at a gage height of 3.20 feet, gave a discharge of 300 second-feet; the third, on September 12, at a gage height of 1.55 feet, gave a discharge of 297 second-feet.

Daily gage height, in feet, of Soldiuck River at Quillayute, Washington, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.20	4.35	5.00	2.75	3.60	3.30	2.85	2.50	1.70	1.70	2.95	9.45
2	3.95	4.10	4.90	2.75	3.40	3.65	2.95	2.40	.65	1.80	2.80	7.65
3	3.70	3.90	4.65	2.90	3.35	3.60	3.45	2.30	65	1.70	2.70	6.60
4	3.55	3.75	4.55	3.20	3.30	3.85	3.20	2.25	1.70	1.60	3.20	6.45
5	3.40	3.65	4.35	3.10	3.25	3.80	3.05	2.20	70	1.50	3.20	6.30
6	3.35	3.55	4.25	3.05	3.25	3.50	2.95	2.30	65	1.50	3.25	6.10
7	3.30	3.60	5.05	3.00	3.30	3.30	2.90	2.30	65	1.55	3.30	5.95
8	3.25	3.65	5.70	2.95	3.50	3.20	2.90	2.25	1.60	1.55	3.55	5.85
9	3.25	4.05	5.10	3.20	4.45	3.40	2.85	2.35	60	1.50	3.45	5.70
10	5.45	4.50	4.90	4.05	4.00	3.80	2.85	2.50	55	1.55	5.40	5.55
11	5.25	4.25	4.60	5.10	5.05	3.85	2.85	2.55	55	1.55	5.30	7.05
12	4.75	4.75	4.55	7.80	4.45	3.80	2.80	2.45	55	1.50	5.10	6.40
13	4.50	5.35	4.45	5.40	4.05	3.85	2.90	2.30	50	1.50	4.55	5.70
14	5.60	6.70	4.25	4.75	3.80	3.35	3.00	2.35	45	1.45	6.50	5.40
15	6.00	9.30	3.95	4.25	3.60	3.30	3.00	2.30	45	1.55	5.70	4.90
16	6.35	6.95	3.75	4.35	3.65	3.45	3.05	2.10	40	1.80	5.35	4.60
17	6.85	7.50	3.60	4.25	3.70	3.75	3.00	2.15	45	2.10	6.30	4.50
18	9.70	6.40	3.50	4.15	3.50	3.60	2.95	2.20	45	2.35	8.20	4.20
19	7.65	6.00	3.40	4.10	3.40	3.45	2.90	2.05	40	2.80	12.70	4.25
20	8.80	5.50	3.35	4.00	3.35	3.35	2.85	2.00	1.40	3.45	9.60	4.35
21	8.75	5.20	3.25	4.05	3.35	3.20	2.65	1.95	40	4.20	8.45	9.30
22	6.85	4.95	3.25	4.05	3.40	3.15	2.60	1.90	35	3.65	7.80	9.50
23	6.10	4.65	3.20	3.80	3.40	3.20	2.60	1.90	35	3.00	7.50	11.20
24	5.80	4.55	3.10	3.70	3.80	3.20	2.55	1.85	1.35	3.00	7.40	9.35
25	5.60	4.45	3.05	3.65	3.90	3.20	2.60	1.85	1.35	2.95	7.15	7.90
26	5.40	4.50	3.00	3.60	3.80	3.20	2.70	1.80	1.35	2.95	7.10	6.40
27	5.05	5.30	2.90	3.65	3.85	3.35	2.70	1.80	1.35	4.10	7.05	5.70
28	4.80	5.10	2.85	3.65	3.75	3.10	2.75	1.75	1.35	5.00	9.40	5.65
29	4.45	.....	2.85	3.70	3.50	3.00	2.80	1.75	1.30	4.30	7.65	5.60
30	4.50	.....	2.80	3.75	3.35	2.90	2.70	1.75	1.55	3.45	10.30	5.80
31	4.65	.....	2.75	.....	3.30	.....	2.60	1.70	.....	3.00	.....	5.60

SACRAMENTO RIVER AT JELLYS FERRY, CALIFORNIA.

This river rises in the extreme northeastern corner of California nd flows in a general southerly direction, draining the large area in orthern California between the Coast Range on the west and the ierra Nevada on the east. It discharges into San Francisco Bay. A umber of storage reservoirs have been constructed on the various ributaries of the river, and are used principally for hydraulic mining urposes and to a less extent for irrigation. The gaging station,

established April 30, 1895, is located 12 miles above the town of Redbluff, at the crossing of the county road at Jellys Ferry. The gage consists of a vertical rod made in three sections and nailed firmly to trees near the ferry landing. A second rod is located 1,206 feet above the gage, and a third one 350 feet below the main rod, in order to determine the slope of the water surface. The three rods are referred to the same datum. Bench mark No. 1 is on an oak tree on the left bank, 1,200 feet above the ferry and 65 feet north of the upper rod, and is 22.724 feet above gage datum. Bench mark No. 2 is on an oak tree on the left bank of the river, 300 feet below the cable, and is 22.429 feet above gage datum. The ferry cable is used in the discharge measurements. The channel for 1,000 feet above and below the station is nearly straight. The right bank is high, but the left bank is liable to overflow when the water rises above the 25-foot mark. The bed of the stream consists of gravel and changes only slightly. Results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 367; 1897, Nineteenth Annual Report, Part IV, page 509; 1898, Twentieth Annual Report, Part IV, page 527. The following measurements of discharge were made under the direction of J. B. Lippincott:

Discharge measurements of Sacramento River at Jellys Ferry, California.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
1898.	*Feet.*	*Second-feet.*	1899.	*Feet.*	*Second-feet.*
December 28	5.3	4,462	April 28	7.3	7,813
			May 13	6.65	7,630
1899.			June 3	6.9	8,409
			June 13	5.9	6,104
January 14	11.4	21,211	June 28	5.5	4,866
January 28	7.5	10,299	July 13	5.25	4,276
February 13	5.9	5,848	July 28	5.05	4,025
February 28	6.1	6,380	August 13	5.0	3,969
March 13	6.15	6,644	August 28	5.0	3,764
March 29	11.5	21,985	September 13	5.0	4,087
April 13	7.8	10,659	September 28	5.0	4,009

aily gage height, in feet, of Sacramento River at Jellys Ferry, California, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.55	7.05	8.40	9.50	6.60	9.20	5.40	5.10	5.00	5.00	5.50	11.20
2	6.10	6.85	8.70	9.30	6.60	7.30	5.40	5.00	5.00	5.00	5.40	9.70
3	6.20	6.70	8.00	8.90	6.50	6.90	5.40	5.00	5.00	5.00	5.40	8.90
4	5.75	6.40	7.50	8.80	6.50	6.70	5.40	5.00	5.00	5.00	5.40	8.30
5	5.65	6.15	7.30	8.70	6.50	6.60	5.40	5.00	5.00	5.00	5.40	8.70
6	5.60	6.00	7.10	8.50	6.50	6.50	5.40	5.00	5.00	5.00	5.40	7.90
7	6.00	6.00	7.00	8.30	6.50	6.30	5.30	5.00	5.00	5.00	5.40	7.60
8	5.95	6.00	6.90	8.40	6.60	6.20	5.30	5.00	5.00	5.00	5.40	7.90
9	5.90	5.90	6.70	8.30	6.50	6.10	5.30	5.00	5.00	5.00	6.40	7.50
10	13.65	5.90	6.60	8.30	6.50	6.10	5.30	5.00	5.00	5.00	10.80	7.40
11	10.05	5.90	6.50	8.10	6.60	6.00	5.30	5.00	5.00	5.00	14.50	8.70
12	7.75	5.90	6.40	8.00	6.60	6.00	5.30	5.00	5.00	5.00	8.20	10.20
13	7.15	5.90	6.30	7.80	6.60	5.90	5.30	5.00	5.00	5.10	7.60	9.00
14	10.90	6.00	6.30	7.70	6.60	5.80	5.30	5.00	5.00	5.10	7.60	8.70
15	16.20	6.00	8.80	7.60	6.50	5.70	5.20	5.00	5.00	5.10	7.00	16.80
16	16.00	6.15	18.95	7.60	6.40	5.70	5.20	5.00	5.00	5.10	7.70	12.40
17	11.05	6.15	12.90	7.50	6.30	5.60	5.20	5.00	5.00	5.00	11.10	11.70
18	13.10	6.20	10.00	7.40	6.30	5.60	5.20	5.00	5.00	5.10	8.70	10.00
19	10.70	6.40	8.80	7.20	6.30	5.50	5.20	5.00	5.00	5.10	9.00	8.90
20	8.85	6.60	8.60	7.20	6.30	5.50	5.20	5.00	5.00	7.65	7.60	8.30
21	8.25	6.70	8.70	7.20	6.20	5.50	5.20	5.00	5.00	7.60	9.10	8.10
22	7.95	6.30	9.70	7.00	6.00	5.50	5.20	5.00	5.00	7.30	9.40	7.80
23	7.65	6.50	14.80	7.00	6.10	5.50	5.10	5.00	5.00	6.90	8.20	7.70
24	7.35	6.50	20.40	7.00	6.10	5.50	5.10	5.00	5.00	5.90	7.60	7.70
25	7.15	6.40	23.00	7.00	6.20	5.60	5.10	5.00	5.00	5.70	7.40	7.40
26	7.15	6.30	16.50	6.90	6.20	5.60	5.10	5.00	5.00	5.60	7.10	7.40
27	7.35	6.10	13.90	6.80	6.20	5.50	5.10	5.00	5.00	5.60	8.20	7.30
28	7.50	6.10	12.40	6.80	6.10	5.50	5.10	5.00	5.00	5.50	17.80	7.20
29	7.55	.....	11.40	6.70	6.10	5.50	5.10	5.00	5.00	5.50	18.20	7.10
30	7.45	.....	10.40	6.70	6.10	5.50	5.10	5.00	5.00	5.40	14.60	8.90
31	7.15	.....	9.80	.....	6.00	.....	5.10	5.00	.....	5.60	.....	8.50

SAN MATEO CREEK, CALIFORNIA.

an Francisco obtains its domestic water supply from a series of ounding reservoirs located in the southern portion of the peninsula veen San Francisco Bay and the Pacific Ocean. The drainage n of these reservoirs ranges in elevation from 250 to 1,800 feet, ı an average of about 750 feet. The hills are undulating. There limited growth of timber on the northern slopes near the summit, a large amount of brush covers other portions of the basin. On southern slopes and crests the hills are frequently bare of brush, are covered with grasses. The Spring Valley Water Company ıs the entire area of the drainage basin and protects the forest ering, not even permitting grazing within its limits. Mr. Herman ussler, chief engineer of the water company, has furnished this e with a statement of the rainfall and run-off of the drainage ins which contribute to the water supply under the control of the ıpany. The table given below extends from 1869 to the present e, and shows the seasonal rainfall, together with the percentage ected in the reservoirs. The record is, therefore, thirty years in gth, and is by far the oldest table of run-off in the State, thus ting it of unusual value. The seasonal year, rather than the calen-, is given. Column No. 1 shows the year; column No. 2 the inches rainfall in the respective basins; column No. 3 the percentage of rainfall which is caught and delivered, the evaporation being ucted. The portion of the discharge table marked "Southeasterly

portion of the watershed southeast of old dam," etc., refers to the area above the reservoir, which was constructed at an early date. At a later period, at a point lower down the stream, the Crystal Springs dam was constructed and flooded water over the top of the original dam and into the valleys of other streams. This explains the change in the description of the drainage basin which occurs in 1888. The portion of the table marked "Above southeasterly and northeasterly portion of peninsula watershed, total Crystal Lake drainage," is for the entire area above the Crystal Springs gage datum. The remarkable variation in percentage strikingly illustrates the necessity for storing water from the drainage basins in order to provide for periods of drought. In the western portion of the drainage basin there was practically no run-off in the season of 1876–77, and in the easterly portion of the basin there was practically no run-off in the seasons of 1881–82, 1882–83, and 1897–98. It would therefore be necessary to store enough water in the reservoirs to furnish a supply for two summers and at least one winter. Another feature of interest in this table is that while the run-off in the seasons of 1881–82 and 1882–83 was practically nothing from the easterly portion of the basin, the percentage of rainfall in the western portion of the watershed was 29.4 and 23, respectively.

Rainfall and run-off from basin of San Mateo Creek, California.

Year.	Rainfall.	Run-off.
Western portion of peninsula watershed:	*Inches.*	*Per cent.*
1869–70	41.95	22.6
1870–71	31.70	9.8
1871–72	80.42	31.4
1872–73	39.31	28.4
1873–74	48.88	29.5
1874–75	44.26	21.2
1875–76	69.24	39.2
1876–77	23.83	.7
1877–78	72.51	37.8
1878–79	56.10	29.2
1879–80	56.14	35.0
1880–81	53.81	43.0
1881–82	31.23	29.4
1882–83	33.89	23.0
1883–84	54.99	33.2
1884–85	38.25	30.0
1885–86	51.90	43.9
1886–87	34.44	29.1
1887–88	37.53	29.2
1888–89	41.17	28.1
1889–90	73.67	44.7
1890–91	37.69	22.8
1891–92	43.10	13.3
1892–93	58.25	24.4
1893–94	54.90	21.8
1894–95	66.93	25.2
1895–96	49.45	21.0
1896–97	50.47	34.0
1897–98	26.26	9.6
1898–99	42.56	17.7
Total	1,450.83	808.2
Mean	48.36	26.94

Year.	Rainfall.	Run-off.
Southeasterly portion of peninsula watershed (southeast from old dam):	*Inches.*	*Per cent.*
1877–78	57.7	29.3
1878–79	43.12	12.3
1879–80	48.01	15.1
1880–81	38.78	34.1
1881–82	23.02	.9
1882–83	23.06	.0
1883–84	40.32	26.8
1884–85	25.67	13.1
1885–86	35.58	25.4
1886–87	28.61	9.7
1887–88	32.96	5.3
1888–89	35.70	7.4
Total	434.53	179.5
Mean	36.21	14.96
Above southeasterly and northeasterly portions of peninsula watershed, total Crystal Lake drainage:		
1889–90	72.68	33.2
1890–91	31.92	24.4
1891–92	24.16	8.0
1892–93	47.07	34.3
1893–94	33.08	29.0
1894–95	55.77	32.8
1895–96	32.62	18.2
1896–97	35.62	18.3
1897–98	18.17	0.0
1898–99	30.37	11.0
Total	381.46	240.1
Mean	38.15	24.01

STANISLAUS RIVER AT OAKDALE, CALIFORNIA.

This river has its source on the western slope of the Sierras Nevada ı California. It drains a country between the basins of Mokelumne iver on the north and Tuolumne River on the south, and flows in a eneral southwesterly direction, entering San Joaquin River 23 miles bove Stockton. A number of canals divert water from this stream, n either side, the principal one being the canal of the Stanislaus and an Joaquin Water Company, which irrigates lands in the vicinity of akdale and between Knights Ferry and Stockton. The present locaion of the station is 1,000 feet below the railroad bridge and one-half ile north of the town of Oakdale, California. The station as first stablished, May 3, 1895, was at the railroad bridge, but on July 30, 898, a cable was stretched across the river at the present location, at I. W. Bell's ranch house. The channel of the river is straight for ome distance above and below the station, but the bed is of sand and able to shift at times of sudden change in the volume of the river.)n this account numerous discharge measurements will have to be ade each year in order to construct an accurate rating curve for the tation.

The canal of the Stanislaus and San Joaquin Water Company diverts ater from Stanislaus River at a point 3 miles above Knights Ferry, r approximately 15 miles above Oakdale. The volume of this canal what is known as Section 3 was rated on June 1, 1898, by turng in various amounts of water and measuring the same with a meter. was found on June 6, 1899, that silt had accumulated in the bottom the flume at the old gage, and a new station was adopted. This oint was rated similarly to the one of the year previous. The supertendent for the canal company, James Y. Beveridge, kindly reports ıe depths of water at this station, and from the rating tables disarges are computed. The observations on the gage rod are accurate, ut during the spring and fall, when the amount of water which is used or irrigation is not important, it is difficult to obtain accurate reports, ecause it is of no particular interest to the canal company to record ıem. The results of measurements may be found as follows: 1896, ighteenth Annual Report, Part IV, page 371; 1897, Nineteenth nnual Report, Part IV, page 511; 1898, Twentieth Annual Report, art IV, page 530. The following measurements of discharge of the tanislaus and San Joaquin Water Company's canal were made under he direction of Mr. J. B. Lippincott during 1899:

[1] May 19, gage height, 0.45 foot; discharge, 73.5 second-feet.
June 6, gage height, 2.37 feet; discharge, 71.40 second-feet.
June 6, gage height, 2.95 feet; discharge, 52.28 second-feet.
June 6, gage height, 3.64 feet; discharge, 30.60 second-feet.
June 6, gage height, 4.85 feet; discharge, 0.00 second-feet.

[1] Measurement made at old station; new rod read 2.28.

Estimated daily discharge of Stanislaus and San Joaquin Water Company's canal for 1899.

Day.	Apr.	May.	June.	July.	Day.	Apr.	May.	June.	July.
1	32	65	69	49	17	66	75	72	57
2	36	62	71	41	18	67	76	68	57
3	0	62	70	33	19	69	74	69	57
4	0	62	70	34	20	71	74	69	54
5	69	62	71	32	21	75	73	67	57
6	0	69	71	41	22	76	76	65	58
7	0	69	72	39	23	73	76	65	57
8	15	72	72	41	24	73	75	64	55
9	36	74	72	43	25	71	74	56	54
10	51	75	73	41	26	67	72	51	47
11	62	74	73	46	27	67	69	50	61
12	65	73	0	62	28	67	67	48	57
13	66	74	65	62	29	67	69	48	0
14	65	72	67	55	30	67	69	53	55
15	61	71	73	52	31	.....	66	.....	53
16	64	73	68	46					

Measurements of Stanislaus River at Oakdale, California.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
March 3	5.13	487	June 28	6.3	1,167
April 20	8.8	3,873	August 3	4.53	143
May 18	7.68	2,634	September 9	4.41	88
June 5	7.94	3,057	December 6	5.41	331
June 18	8.42	3,599			

Daily gage height, in feet, of Stanislaus River at Oakdale, California, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.30	5.00	5.20	7.60	6.60	7.50	6.00	4.60	4.40	4.50	5.00	5.60
2	4.80	5.00	5.10	7.40	6.50	7.60	6.10	4.50	4.40	4.50	4.80	5.60
3	5.60	4.80	5.10	7.20	6.60	7.60	6.00	4.50	4.50	4.40	4.80	5.70
4	4.80	4.80	5.00	7.20	6.50	7.70	5.90	4.50	4.40	4.40	4.60	5.60
5	4.60	4.60	5.00	7.80	6.60	7.60	5.80	4.60	4.40	4.40	4.50	5.40
6	4.50	4.50	4.80	7.80	6.70	8.40	5.60	4.60	4.50	4.40	4.60	5.30
7	4.50	4.50	4.80	8.70	6.80	8.20	5.60	4.80	4.40	4.50	4.40	5.40
8	4.40	4.60	4.70	8.80	7.00	8.50	5.60	4.80	4.40	4.40	4.40	5.40
9	4.40	4.60	4.80	9.60	7.60	8.20	5.50	4.70	4.40	4.50	5.20	5.30
10	5.10	4.60	5.00	9.80	8.00	8.30	5.50	4.60	4.30	4.50	6.40	5.40
11	6.25	4.70	4.80	9.00	9.20	8.50	5.50	4.60	4.40	4.50	7.20	5.40
12	5.40	4.70	4.80	9.00	10.20	9.30	5.40	4.60	4.50	4.50	7.00	5.80
13	5.00	4.70	4.80	8.80	10.00	8.60	5.40	4.60	4.50	4.60	6.80	7.80
14	4.80	4.80	5.00	9.00	9.20	8.30	5.30	4.50	4.40	5.00	6.40	6.00
15	5.00	4.80	5.50	8.80	8.60	8.20	5.10	4.60	4.40	5.00	6.40	7.00
16	4.80	4.70	6.90	9.60	8.60	8.00	5.10	4.50	4.40	4.80	7.40	9.60
17	4.80	4.80	6.00	9.60	8.20	8.40	5.00	4.50	4.40	4.50	7.00	8.80
18	5.00	5.00	5.60	9.10	7.80	8.50	4.90	4.50	4.30	4.40	7.00	8.40
19	5.20	5.30	5.40	8.80	7.40	8.20	4.80	4.50	4.30	4.40	6.80	7.50
20	5.20	5.50	7.80	8.80	7.20	7.60	4.60	4.50	4.30	4.60	6.60	7.00
21	5.50	5.50	6.10	8.90	7.30	7.10	4.60	4.50	4.30	4.80	6.20	6.80
22	5.50	5.40	5.90	9.10	7.50	7.00	4.70	4.50	4.30	5.80	7.00	6.50
23	5.40	5.40	11.10	8.80	7.70	6.90	4.80	4.60	4.20	6.20	6.60	6.30
24	5.40	5.30	13.30	8.60	7.50	6.90	4.80	4.70	4.30	6.00	6.20	6.20
25	5.50	5.20	16.60	8.20	7.10	6.60	4.70	4.40	4.30	5.60	5.80	6.20
26	5.50	5.20	11.70	7.60	6.80	6.60	4.70	4.40	4.20	5.40	6.00	6.00
27	5.50	5.20	10.00	7.40	6.80	6.40	4.70	4.40	4.20	5.20	6.00	6.00
28	5.60	5.20	10.30	7.00	6.80	6.40	4.60	4.40	4.30	5.00	5.80	6.20
29	5.40	.....	9.00	7.00	6.80	6.10	4.70	4.40	4.40	4.80	5.70	6.00
30	5.20	.....	8.60	6.50	7.00	6.00	4.70	4.50	4.40	5.00	5.80	6.40
31	5.20	.....	8.00	.....	7.00	.....	4.60	4.40	.....	4.80	.....	6.80

TUOLUMNE RIVER AT LAGRANGE, CALIFORNIA.

This river rises on the western slope of the Sierras Nevada in California, and drains the country located between Stanislaus River on the orth and Merced River on the south. The northern half of the osemite National Park includes a portion of the drainage basin of his stream. The river is fed largely from small mountain lakes occurring high in the drainage basin, where the snow remains on the mountain slopes throughout the year, thus insuring a large run-off. The tream has a heavy fall, and the opportunities for power development re numerous. There are also a number of reservoir sites in the basin here water could be stored during the irrigation season. The station, stablished August 29, 1895, is located at the wagon bridge in the town f Lagrange, California. The rod is vertical and bolted to the right-and pier of the bridge. The bench mark is a nail driven into the ottom of the west post of the fifth bent south of the south iron cylinder, and is 15.31 feet above gage datum. The station is located below he high dam of the Turlock and Modesto irrigation districts, and also elow the head of the canal of the Lagrange Hydraulic Mining Company. This latter canal diverts water from the left bank of the river miles above Lagrange dam. During 1898 water was first turned own the Turlock canal in small quantity, and was used for puddling he banks and testing dams of certain reservoirs. Whenever measurements at the gaging station were made, the Turlock canal and the ining company's canal were also measured. The channel at the tation, both above and below the bridge, is straight for several hunred feet, and the velocity of the stream is quite uniform. Both banks re high and not subject to overflow. The results of measurements ay be found as follows: 1896, Eighteenth Annual Report, Part IV, age 381; 1897, Nineteenth Annual Report, Part IV, page 513; 1898, wentieth Annual Report, Part IV, page 532. The following measrements were made under the direction of J. B. Lippincott during 399:

Discharge measurements of Turlock canal for 1899.

April 20, discharge, 10 second-feet.
April 21, discharge, 10 second-feet.
May 19, discharge, 61 second-feet.
June 6, discharge, 10 second-feet.
June 29, discharge, 18 second-feet.
August 3, discharge, 85 second-feet.
September 11, discharge, 29 second-feet.

Estimated daily discharge of Turlock canal for 1899.[a]

Day.	July.	Aug.	Sept.	Oct.	Nov.	Day.	July.	Aug.	Sept.	Oct.	Nov.
1	5	80	34	10	3	17	10	85	10	10	0
2	5	80	34	10	3	18	48	85	10	1	0
3	5	80	34	10	3	19	48	85	10	1	0
4	5	80	34	10	3	20	48	85	10	1	0
5	5	80	34	10	3	21	10	86	10	1	0
6	5	80	34	10	3	22	5	86	10	3	0
7	5	1	34	10	3	23	8	10	10	3	0
8	5	20	34	10	3	24	8	8	10	3	0
9	10	20	34	10	3	25	1	8	10	3	0
10	10	85	34	10	3	26	1	8	10	3	0
11	10	85	34	10	3	27	1	10	10	3	0
12	10	85	8	10	1	28	1	10	10	3	0
13	10	85	8	10	1	29	1	10	10	3	0
14	10	85	8	10	0	30	8	10	10	3	0
15	10	85	10	10	0	31	28	10	.....	3	.....
16	10	85	10	10	0						

[a] The quantities are not included in volumes discharged at the Lagrange bridge. There was no flow during the months of January to June, inclusive, nor during December.

Discharge measurements of Lagrange Hydraulic and Mining Company's canal for 1899.

April 20, discharge, 23.5 second-feet.
April 21, discharge, 23.5 second-feet.
May 19, discharge, 24 second-feet.
June 6, discharge, 24 second-feet.
June 29, discharge, 24 second-feet.
August 3, discharge, 24 second-feet.
September 11, discharge, 24 second-feet.

Discharge measurements of Tuolumne River at Lagrange, California, for 1899.

March 3, gage height, 5 feet; discharge, 774 second-feet.
April 20, gage height, 7.55 feet; discharge, 5,712 second-feet.
April 21, gage height, 7.85 feet; discharge, 6,943 second-feet.
May 19, gage height, 6.72 feet; discharge, 3,616 second-feet.
June 6, gage height, 8.47 feet; discharge, 8,964 second-feet.
June 29, gage height, 6.15 feet; discharge, 2,347 second-feet.
August 3, gage height, 3.70 feet; discharge, 23 second-feet.
September 11, gage height, 3.58 feet; discharge, 12 second-feet.

Daily gage height, in feet, of Tuolumne River at Lagrange, California, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.10	4.77	5.00	6.60	6.10	7.10	6.20	4.40	3.80	3.70	5.30	5.60
2	4.30	4.75	5.00	6.50	6.00	6.90	6.10	4.30	3.80	3.65	5.00	5.50
3	4.60	4.70	5.00	6.60	6.00	6.80	6.00	4.20	3.70	3.60	4.90	5.40
4	4.30	4.70	4.90	6.40	6.00	7.20	6.00	4.20	3.70	3.60	4.90	5.40
5	4.27	4.65	4.90	6.90	6.30	8.10	5.90	4.10	3.70	3.55	4.90	5.30
6	4.20	4.60	4.90	7.10	6.10	8.50	5.80	4.00	3.70	3.55	4.90	5.20
7	4.22	4.62	5.10	7.40	6.10	8.50	5.70	4.00	3.70	3.55	5.10	5.20
8	4.35	4.62	5.20	7.60	6.40	8.40	5.60	4.50	3.70	3.50	5.60	5.20
9	4.32	4.63	5.30	7.90	6.90	8.70	5.50	4.60	3.70	3.50	6.20	5.20
10	4.32	4.67	5.20	7.80	7.40	8.80	5.40	4.50	3.60	3.50	7.70	5.10
11	5.95	4.75	5.10	7.80	8.10	8.80	5.30	4.50	3.70	3.50	7.10	5.20
12	5.12	4.75	5.00	7.80	8.30	8.70	5.20	4.40	3.70	3.50	7.00	5.50
13	4.72	4.85	4.80	7.90	8.40	8.50	5.20	4.80	3.70	3.50	6.30	6.60
14	4.60	4.95	4.80	8.00	8.30	8.00	5.10	4.10	3.80	4.70	6.00	7.30
15	4.42	5.00	4.90	8.10	7.40	7.90	5.10	3.90	3.80	4.60	6.50	7.90
16	4.35	4.90	6.60	8.20	7.90	8.00	5.00	4.00	3.80	4.60	7.10	8.20
17	4.92	4.90	6.30	7.90	7.00	7.90	5.00	3.90	3.80	4.40	6.80	6.90
18	4.92	5.02	5.70	7.80	7.30	7.80	4.90	3.90	3.80	4.60	6.70	6.80
19	4.92	5.20	5.60	7.50	7.30	7.70	4.90	3.90	3.80	4.70	6.70	6.90
20	4.82	5.40	6.20	7.60	7.70	7.80	4.90	3.90	3.75	4.80	6.50	6.80
21	4.80	5.60	5.90	7.80	7.30	7.40	4.80	3.80	3.70	4.80	6.70	7.00
22	4.80	5.50	5.80	7.80	7.10	6.90	4.80	3.80	3.60	6.10	6.60	6.80
23	4.87	5.40	9.10	7.50	7.40	6.80	4.70	4.10	3.70	5.70	6.50	6.90
24	4.82	5.40	11.40	6.70	7.30	6.80	4.70	4.10	3.70	5.40	6.80	6.80
25	4.72	5.30	12.50	6.60	7.00	6.50	4.70	4.00	3.70	5.20	5.68	6.80
26	4.72	5.20	8.60	6.40	6.40	6.30	4.70	4.00	3.70	5.20	5.60	6.90
27	4.80	5.10	7.70	6.30	6.40	6.40	4.70	3.90	3.65	5.10	5.40	6.70
28	4.85	5.10	7.50	6.30	6.50	6.20	4.60	3.80	3.70	5.00	5.60	6.70
29	4.97	.....	7.10	6.20	6.90	6.10	4.60	3.80	3.70	5.00	5.70	6.90
30	4.92	.....	6.80	6.10	6.90	6.10	4.55	3.90	3.60	5.50	5.60	6.80
31	4.80	.....	6.60	.....	6.90	.....	4.50	3.80	.....	5.50	.....	6.40

SAN JOAQUIN RIVER AT HERNDON, CALIFORNIA.

The headwater tributaries of this river receive the drainage from crests of the Sierras Nevada north of Mount Whitney. The fall the river is rapid, with many favorable locations for power developnt, and in one case advantage has been taken of the fall on the rth Fork and a power plant constructed developing electric power transmission to Fresno and Hanford, California. During the last ar a second storage reservoir has been under course of construcn on the North Fork, which will tend further to regulate the flow the river. No permanent diversions above the gaging station are de, but the water is extensively used below for irrigation purposes. e station was established by the Southern Pacific Railway Company 1879. The old trestle bridge was torn down by the railroad comny during the last year and a new iron structure was erected in place. This necessitated a new gage rod, which was referred the datum of the old gage and bolted to the western side of the ntral concrete pier. The bench mark is a nail in a post at the uth end of the bridge on the west side, 0.2 foot above the ground d marked "B. M." It is at an elevation of 24.12 feet above gage tum. The channel for some distance above and below the bridge straight and the water has a uniform velocity. The right bank is h, rocky, and steep. The bed of the stream is of sand and gravel. e results of measurements may be found as follows: 1896, Eighteenth nual Report, Part IV, page 387; 1897, Nineteenth Annual Report,

Part IV, page 515; 1898, Twentieth Annual Report, Part IV, page 529. The following discharge measurements were made under the direction of J. B. Lippincott during 1899:

Discharge measurements of San Joaquin River at Herndon, California.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
March 5	3.25	786	June 27	4.90	2,922
April 18	6.34	5,310	August 1	3.32	743
May 13	7.00	7,435	September 8	2.67	196
June 2	5.76	4,177	September 8 *a*	.....	269

a This measurement was made at Pollasky, California. The measurement made at the regular gaging station at 6 p. m. showed a loss by evaporation, etc., of 73 second-feet in 18 miles.

Daily gage height, in feet, of San Joaquin River at Herndon, California, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.67	3.17	3.25	4.71	4.29	5.63	5.08	3.33	2.67	2.33	2.75	3.00
2	2.67	3.17	3.25	4.58	4.38	5.63	4.96	3.25	2.67	2.33	2.70	3.00
3	2.67	3.17	3.25	4.42	4.25	5.42	5.00	3.25	2.67	2.33	2.63	3.00
4	2.75	3.08	3.25	4.42	4.25	5.38	4.96	3.25	2.67	2.33	2.67	3.00
5	2.67	3.00	3.25	4.62	4.29	5.71	4.92	3.25	2.67	2.33	2.67	3.00
6	2.67	3.00	3.25	4.67	4.38	6.54	4.63	3.00	2.67	2.33	2.67	3.00
7	2.67	3.00	3.25	5.75	4.50	7.13	4.54	3.00	2.67	2.33	2.58	2.75
8	2.67	3.00	3.25	5.67	4.50	7.17	4.42	3.00	2.67	2.25	2.58	2.75
9	2.92	2.92	3.42	6.33	4.71	7.50	4.25	3.08	2.67	2.25	2.58	2.75
10	3.00	2.92	3.42	6.29	5.25	7.75	4.21	3.08	2.67	2.25	2.50	2.75
11	3.25	3.00	3.42	6.04	6.21	7.67	4.17	3.17	2.67	2.25	3.50	2.75
12	3.67	3.00	3.33	6.17	6.96	7.58	4.17	3.17	2.58	2.25	3.25	2.67
13	3.25	3.00	3.25	6.21	6.96	7.42	4.17	3.08	2.50	2.33	3.58	3.00
14	3.00	3.00	3.25	6.38	6.71	7.13	3.96	3.08	2.50	2.42	3.67	2.87
15	3.00	3.00	3.25	6.58	6.13	7.00	3.92	3.00	2.50	2.42	3.50	3.20
16	3.00	3.08	3.25	7.08	5.67	6.96	3.88	2.92	2.50	2.58	3.29	6.00
17	3.08	3.17	3.62	6.70	5.63	6.92	3.83	2.92	2.50	2.58	3.63	5.12
18	3.08	3.17	3.50	6.29	5.58	6.79	3.83	2.83	2.50	2.58	3.50	4.16
19	3.08	3.17	3.33	6.33	5.58	6.71	3.75	2.83	2.42	2.66	3.29	4.10
20	3.08	3.50	3.37	6.21	5.46	6.79	3.75	2.83	2.42	2.66	3.17	3.91
21	3.08	3.54	3.62	6.25	5.25	6.50	3.75	2.83	2.42	2.66	3.17	3.83
22	3.00	3.58	3.67	6.17	5.54	6.00	3.75	2.83	2.42	2.75	3.17	3.67
23	3.17	3.58	4.58	6.25	6.00	5.88	3.75	2.83	2.42	3.33	3.33	3.54
24	3.08	3.58	9.21	5.91	6.08	5.67	3.58	2.83	2.33	3.33	3.21	3.33
25	3.08	3.58	10.40	5.38	5.92	5.88	3.50	2.83	2.33	3.00	3.17	3.33
26	3.00	3.42	8.75	5.04	5.58	5.67	3.67	2.83	2.33	3.00	3.25	3.25
27	3.00	3.33	7.17	5.00	5.25	5.13	3.75	2.83	2.33	2.96	3.08	3.25
28	3.17	3.25	5.75	4.92	5.17	4.83	3.54	2.83	2.33	2.86	3.08	3.25
29	3.17	.....	5.62	4.88	5.17	4.96	3.50	2.75	2.33	2.80	3.00	3.25
30	3.17	.....	5.37	4.54	5.79	5.00	3.50	2.75	2.33	2.80	3.00	3.25
31	3.17	.....	4.91	.....	5.38	.....	3.50	2.75	.....	2.75	.....	5.90

[Continued in Water-Supply and Irrigation Paper No. 39.]

O

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 39

OPERATIONS AT UPPER STATIONS, 1899.—PART V

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

IRRIGATION REPORTS.

The following list contains titles and brief descriptions of the principal [illegible] relating to water supply and irrigation prepared by the United States Geological Survey since 1880.

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 17[illegible]

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, a general report on the organization and prosecution of the survey of the arid lands for pleasure [illegible] geology, and report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo, [illegible]

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889-90. Contains a description of the hydrography of the arid region and [illegible] engineering discussions carried on in the Irrigation Survey during 1890, also the annual [illegible] the Director of the Survey to the House Committee on Irrigation, and other papers, [illegible] hydrography of irrigation locations. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1892; octavo, 17[illegible]

Published as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890-91. Contains "Report upon the location and survey of reservoir sites during the year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; "Irrigation in Idaho," by Herbert M. Wilson. Illustrated by 30 plates and [illegible]

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell; quarto.

No. 35, Irrigation in Arizona; No. 69, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 165, Irrigation in Nevada; No. 178, Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. [illegible] September 9, 1892; quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, total area and average size of irrigated farms in the arid and semi-arid regions, the percentage of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a resume of the water supply and a description of irrigation by artesian wells. Illustrated by colored maps showing the location and relative [illegible] of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-92, Part [illegible] Irrigation, 1893; octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American [illegible] ation engineering" and "Engineering results of the Irrigation Survey," by Herbert M. Wilson; "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, [illegible] octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent [illegible] drainage basin of Yakima River and the great plains of the Columbia to the east of this [illegible] with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States, the [illegible] irrigated, cost of works, their value and profits; also describes the water supply, the [illegible] water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and describes the physical conditions and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892-93, in [illegible] parts; Part II, Accompanying papers, 1894; octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W. J. McGee; "[illegible] mineral waters of the United States," by A. C. Peale; and "Results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 39

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

J. C. Branner

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

PERATIONS AT RIVER STATIONS, 1899

A REPORT OF THE

DIVISION OF HYDROGRAPHY

OF THE

UNITED STATES GEOLOGICAL SURVEY

PART V

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

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OPERATIONS AT RIVER STATIONS, 1899.

PART V.

MEASUREMENTS AT RIVER STATIONS.[1]

KINGS RIVER AT RED MOUNTAIN, CALIFORNIA.

This river rises on the western slope of the Sierra Nevada in Fresno unty, California. The waters coming from the high catchment basin probably of greater value for irrigation purposes than those of any er stream in central California, being used exclusively for the rais- of grapes and deciduous fruits in the neighborhood of Fresno, ma, and Hanford. The summer flow of this river is now entirely erted, and during the dry season of the last few years the scarcity water has worked many hardships. There is a large surplus of ter in this river in the spring of the year, due to the melting of ws, which is now going to waste, and which, if stored in suitable ervoirs, would bring larger areas under cultivation. The moun- ous basin of this river has never been systematically explored for ervoir sites. Two gaging stations were formerly maintained on river; one at Red Mountain and the other at Kingsburg, Califor- . The station at Red Mountain, established September 3, 1895, is ated 15 miles east of Sanger, California, and southwest of Red untain. The station is on what is called "the lower section of No. of the lumber flume. It is located at the mouth of the canyon, ve all diversions. The bed of the stream is of gravel, and few nges have been noticed in the cross section since the establishment the station. The results of measurements may be found as follows: 6, Eighteenth Annual Report, Part IV, page 392; 1897, Nineteenth nual Report, Part IV, page 519; 1898, Twentieth Annual Report, t IV, page 535. The following discharge measurements were made ler the direction of J. B. Lippincott during 1899:

Discharge measurements of Kings River at Red Mountain, California.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
April 19	8.8	5,409	August 2	4.66	608
May 15	8.15	4,422	September 4	3.8	206
June 3	7.85	3,954	December 8	4.36	458
June 26	7.23	3,049	December 21	5.3	a 974

a Measured at point 2 miles below gaging station.

[1] Continued from Water-Supply and Irrigation Paper No. 38.

Daily gage height, in feet, of Kings River at Red Mountain, California, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.80	4.60	4.90	6.40	6.90	8.50	7.30	4.70	3.80	3.60	4.20	4.50
2	3.80	4.70	4.90	6.40	6.80	8.40	7.30	4.70	3.80	3.60	4.20	4.40
3	4.00	4.60	4.90	6.50	6.80	8.40	7.30	4.60	3.80	3.60	4.10	4.40
4	4.20	4.40	4.90	6.60	6.80	8.00	7.10	4.50	3.90	3.60	4.20	4.40
5	3.90	4.40	4.90	7.60	6.00	8.70	6.50	4.40	3.90	3.60	4.20	4.50
6	3.90	4.40	5.00	7.80	7.00	10.00	6.80	4.40	3.80	3.60	4.10	4.40
7	4.00	4.30	5.00	8.00	7.10	10.10	6.50	4.50	3.80	3.60	4.10	4.20
8	4.20	4.40	5.10	8.40	7.80	10.00	6.30	4.50	3.70	3.60	4.05	4.30
9	4.10	4.40	5.20	8.60	7.70	10.20	6.20	4.40	3.80	3.60	4.80	4.40
10	4.20	4.50	5.10	8.60	7.80	10.30	6.10	4.40	3.70	3.60	5.50	4.20
11	5.80	4.50	5.10	8.70	7.90	10.40	6.00	4.40	3.70	3.65	4.80	4.30
12	5.00	4.50	4.90	8.70	7.70	10.50	5.90	4.30	3.70	3.70	5.40	4.40
13	4.70	4.50	4.80	8.70	7.80	10.00	5.80	4.20	3.80	3.85	5.10	4.40
14	4.60	4.60	4.80	9.00	7.90	9.40	5.70	4.20	3.70	3.95	4.90	4.60
15	4.50	4.60	4.70	9.30	7.70	9.60	5.60	4.20	3.70	4.00	4.70	5.40
16	4.60	4.60	4.90	9.50	7.80	9.50	5.60	4.20	3.70	4.50	5.70	8.60
17	4.60	4.70	4.90	8.90	7.90	9.50	5.50	4.20	3.70	4.10	5.20	6.40
18	4.60	4.70	5.00	9.10	8.00	9.40	5.40	4.10	3.70	4.20	5.00	5.80
19	4.60	4.80	5.00	8.60	8.20	9.10	5.50	4.20	3.60	4.25	4.80	5.60
20	4.50	5.10	5.40	9.00	7.70	9.00	5.40	4.10	3.70	4.25	4.60	5.40
21	4.50	5.40	5.50	9.20	8.30	8.50	5.30	4.10	3.60	4.30	4.70	5.30
22	4.50	5.40	6.40	9.30	8.20	8.30	5.30	4.00	3.60	5.65	5.00	5.20
23	4.60	5.30	7.80	9.00	8.30	8.10	5.20	4.10	3.60	5.40	4.80	5.20
24	4.50	5.30	9.70	8.30	8.40	8.10	5.10	4.00	3.60	4.70	4.70	5.20
25	4.50	5.30	13.80	8.30	8.00	7.70	5.30	4.00	3.60	4.50	4.70	5.20
26	4.50	5.10	8.20	7.70	7.90	7.50	5.30	3.90	3.60	4.45	4.70	5.20
27	4.50	4.90	7.70	7.50	7.90	7.10	5.20	3.90	3.60	4.45	4.70	5.20
28	4.60	4.90	7.10	7.70	8.40	7.30	5.10	3.90	3.60	4.40	4.60	5.10
29	4.60	.....	7.30	6.60	8.50	7.30	5.00	3.90	3.60	4.40	4.60	5.10
30	4.70	.....	6.80	7.10	8.40	7.30	4.90	3.90	3.60	4.35	4.50	7.10
31	4.60	.....	6.20	.....	7.90	.....	4.80	3.80	.....	4.30	.....	6.40

KINGS RIVER AT KINGSBURG, CALIFORNIA.

The Southern Pacific Railway Company has maintained gage readings at the railroad bridge 1 mile south of Kingsburg since 1879. Attempts have been made in previous years to establish a rating curve for this station, but it has been found impossible to do so on account of the fluctuations of the water surface caused by the manipulation of the head gates of the People's canal, 2 miles below, and also on account of the changes in the sandy bed of the river. The railroad company has maintained daily gage readings as given on the following page. No measurements of discharge were made at this point during 1899.

Daily gage height, in feet, of Kings River at Kingsburg, California, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.92	4.16	3.83	4.08	4.83	6.75	5.67	4.00	3.25	2.83	3.92	5.08
2	3.92	4.08	3.83	4.25	4.58	6.92	5.50	4.00	3.25	2.25	3.83	5.08
3	4.00	4.08	3.92	4.00	4.25	6.67	5.42	4.00	3.25	2.25	3.83	5.08
4	4.00	4.08	3.83	4.17	4.33	6.58	5.00	4.00	3.25	2.25	3.83	5.08
5	3.92	4.16	3.92	4.25	4.42	6.83	4.92	3.92	3.25	2.25	3.75	5.08
6	3.92	4.25	3.92	4.66	4.58	8.00	4.50	3.83	3.25	2.25	3.75	5.08
7	4.00	4.25	3.92	6.33	4.83	8.50	4.33	3.75	3.25	2.25	3.67	5.33
8	4.00	4.33	3.83	6.75	5.25	8.50	4.25	3.83	3.25	2.25	3.67	5.08
9	4.00	4.33	3.83	7.00	5.08	8.58	4.58	3.83	3.25	2.25	3.83	5.08
10	4.00	4.25	3.83	7.08	5.50	8.58	4.25	3.83	3.21	2.25	4.25	5.08
11	5.42	4.25	3.83	7.08	7.00	9.00	4.00	3.75	3.25	2.25	5.25	4.75
12	5.83	4.25	3.83	7.00	8.17	9.00	3.67	3.58	3.25	2.25	4.92	4.83
13	4.33	4.16	3.75	7.00	8.33	8.75	3.75	3.58	3.25	2.25	5.50	4.92
14	3.66	4.16	3.92	7.17	8.08	8.00	4.00	3.54	3.21	2.33	5.25	5.75
15	3.92	4.16	3.83	7.25	7.17	8.00	4.17	3.50	3.25	2.75	5.17	5.25
16	3.92	4.16	3.92	7.75	7.00	7.83	4.00	3.46	3.25	3.08	5.42	8.00
17	3.92	4.16	3.92	7.50	6.50	7.50	4.17	3.60	3.25	3.17	5.83	7.33
18	4.00	4.00	3.92	7.25	6.67	7.50	4.25	3.25	3.25	3.25	5.67	6.83
19	3.92	4.00	3.83	7.08	6.67	7.25	4.33	3.25	3.25	3.50	5.42	6.50
20	4.08	4.25	3.92	7.00	6.58	7.33	4.25	3.25	3.25	3.67	5.25	6.25
21	4.00	4.25	3.92	7.25	6.25	7.00	4.17	3.21	3.25	3.75	5.33	6.00
22	4.00	4.25	3.92	7.17	6.33	6.83	4.17	3.17	3.17	4.17	5.25	6.00
23	4.08	4.16	3.83	7.08	6.75	6.83	4.08	3.17	3.17	5.67	5.42	5.83
24	4.16	4.25	9.33	7.00	7.67	6.50	4.00	3.17	3.17	5.00	5.25	5.75
25	4.00	3.83	11.25	6.25	7.00	6.50	4.00	3.12	3.17	4.58	5.17	5.50
26	4.00	3.83	8.92	5.83	6.58	6.25	4.00	3.08	3.12	4.33	5.08	6.00
27	4.08	4.00	6.75	5.33	6.33	6.25	4.08	3.08	3.08	4.08	5.08	6.00
28	4.08	4.00	5.50	5.17	6.25	5.50	3.92	3.00	3.08	4.00	5.08	5.83
29	4.08	.....	5.33	4.92	6.42	5.58	4.00	3.00	3.08	4.00	5.17	6.00
30	4.16	.....	4.75	4.66	6.75	5.75	4.00	3.00	3.08	3.96	5.17	5.83
31	4.16	.....	4.42	.....	6.50	.....	4.00	3.25	.....	3.92	.....	7.50

KERN RIVER NEAR BAKERSFIELD, CALIFORNIA.

This river issues from the southern extremity of the Sierra Nevada, being formed by the junction of the North Fork and the South Fork a short distance below Kernville. The run-off from this basin is notably less than from the northern tributaries of San Joaquin River, which may be due to the fact that a portion of the basin is located east of the main crest of the mountains and is therefore protected from the water-bearing clouds. Most of the water of Kern River is used for irrigation by the large canals in the southern end of San Joaquin Valley. The winter waters are in part stored in Buena Vista Lake, which was a number of years ago converted into a storage reservoir. The station was established in 1893 by Mr. Walter James, chief engineer of the Kern County Land Company, and is located at what is known as "the first point of measurement," 5 miles above Bakersfield and at the mouth of the canyon of the river. Meter measurements are taken once a week, and an automatic gage records the fluctuations of the river heights. Mr. A. K. Warren, the engineer in charge of this work for the Kern County Land Company, attends to the measurements with much accuracy and precision, and furnishes this office with the final results. The results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 297; 1897, Nineteenth Annual Report, Part IV, page 523; 1898, Twentieth Annual Report, Part IV, page 536.

Daily discharge, in second-feet, of Kern River at "first point of measurement," California.

1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	379	766	740	1,100	1,009	3,067	1,299	713	384	241	397	339
2	377	732	713	1,044	994	3,200	1,244	671	365	240	384	319
3	382	695	724	1,015	1,011	2,875	1,221	642	339	241	384	335
4	404	660	690	974	1,074	2,628	1,237	607	328	246	364	350
5	393	639	685	942	1,126	2,592	1,434	590	289	247	349	357
6	379	640	707	916	1,205	2,741	1,879	542	279	250	338	365
7	378	624	695	889	1,146	2,854	1,929	514	312	251	333	370
8	394	593	695	861	1,115	3,069	1,698	496	428	236	328	351
9	400	580	705	870	1,086	3,348	1,570	475	454	228	316	325
10	403	591	726	932	1,015	3,379	1,822	451	399	232	321	339
11	397	598	726	925	978	3,118	1,874	450	360	239	347	338
12	390	598	732	911	952	2,939	1,792	442	329	243	406	339
13	385	599	755	970	986	3,028	1,624	440	305	243	385	332
14	387	591	777	1,045	1,082	2,960	1,447	412	294	241	380	387
15	397	590	822	1,151	1,175	2,801	1,272	381	285	238	380	386
16	397	583	827	1,050	1,173	2,715	1,116	366	269	239	365	369
17	469	576	833	933	1,140	2,686	1,056	379	257	238	351	370
18	519	593	864	864	1,175	2,786	1,144	478	244	250	349	342
19	918	590	867	852	1,205	2,553	1,096	588	247	247	341	322
20	915	582	880	850	1,204	2,300	1,027	644	251	254	345	330
21	3,101	577	924	842	1,184	2,138	963	602	258	268	349	342
22	2,327	572	1,068	832	1,229	1,985	986	536	275	262	354	358
23	1,390	577	1,133	861	1,222	1,884	1,219	481	276	258	356	339
24	1,057	571	1,209	864	1,247	1,680	2,004	442	273	265	355	342
25	888	587	1,232	920	1,362	1,553	1,686	425	282	268	374	341
26	844	596	1,375	1,171	1,568	1,442	1,380	412	282	265	387	342
27	844	618	1,782	1,245	1,971	1,333	1,179	401	280	302	351	347
28	1,125	661	1,648	1,201	2,489	1,301	1,029	386	268	364	326	362
29	906	724	1,453	1,088	2,998	1,346	903	378	248	403	299	378
30	867	.....	1,295	1,055	3,283	1,369	830	364	237	376	329	352
31	757	.....	1,211	.....	3,042	.....	765	310	.....	393	.....	356
Mean	747	617	951	972	1,401	2,456	1,346	486	304	267	355	347

1897.

1	386	1,458	777	1,251	4,163	4,045	1,347	631	341	288	391	382
2	355	2,065	846	1,238	4,185	3,638	1,387	606	345	297	377	381
3	319	1,310	787	1,141	4,187	3,428	1,442	606	344	310	357	388
4	314	963	782	1,130	4,536	3,312	1,439	607	347	312	348	342
5	338	822	714	1,274	4,857	3,308	1,311	600	347	303	345	332
6	357	1,292	694	1,516	4,948	3,352	1,260	575	342	290	338	348
7	351	1,169	857	1,816	4,845	3,387	1,175	536	330	293	340	352
8	352	978	849	2,025	4,658	3,260	1,072	507	309	297	346	368
9	361	791	789	2,141	4,504	3,087	1,002	525	297	297	345	733
10	365	660	818	2,354	4,425	3,062	958	511	288	303	322	680
11	367	632	837	2,580	4,505	2,890	957	493	287	309	329	564
12	357	606	827	2,811	4,567	2,600	1,010	457	294	303	339	509
13	360	605	789	3,116	4,577	2,540	1,055	438	295	299	340	474
14	363	562	763	3,376	4,610	2,527	1,142	424	297	315	336	476
15	369	534	756	3,564	4,531	2,413	1,156	412	295	380	330	482
16	370	532	741	3,822	4,482	1,189	1,151	417	290	392	321	446
17	357	544	780	3,953	4,355	1,853	1,108	423	285	377	303	406
18	337	609	780	4,216	4,252	1,617	1,045	448	278	368	302	397
19	327	678	855	4,217	4,338	1,492	988	438	272	360	306	401
20	318	619	936	3,973	4,470	1,423	947	424	268	353	312	406
21	324	635	906	3,681	4,617	1,374	868	440	269	341	317	358
22	336	626	843	3,526	4,815	1,351	868	467	273	334	328	344
23	343	573	831	3,412	5,066	1,393	840	459	280	346	417	358
24	353	573	850	3,212	5,227	1,403	782	423	286	366	415	387
25	363	617	921	3,140	5,083	1,433	740	393	288	394	436	403
26	372	684	1,079	3,368	4,802	1,431	710	386	286	382	441	408
27	369	749	1,256	3,585	4,614	1,386	688	391	279	372	402	399
28	392	771	1,298	3,865	4,548	1,368	679	396	281	387	403	387
29	452	.....	1,891	4,060	4,479	1,356	681	388	271	386	392	388
30	575	.....	1,471	4,056	4,407	1,349	674	368	274	386	383	384
31	667	.....	1,291	.....	4,340	.....	658	350	.....	390	.....	376
Mean	373	809	923	2,914	4,580	2,309	1,006	469	298	340	355	422

Daily discharge, in second-feet, of Kern River at "first point of measurement," California—Continued.

1898.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	381	332	435	390	877	608	399	132	115	220	136	195
2	379	346	414	385	790	645	365	134	117	203	141	198
3	392	357	430	400	711	662	330	125	111	191	152	195
4	388	356	436	401	678	597	308	127	108	190	158	192
5	384	344	422	381	670	563	303	131	108	181	166	192
6	388	355	402	414	632	597	304	133	107	177	173	191
7	381	639	418	474	580	634	325	136	108	173	181	192
8	381	704	427	465	613	641	341	139	105	165	175	191
9	391	569	434	451	659	635	319	131	102	156	163	184
10	368	483	458	488	712	613	288	125	101	156	161	179
11	354	469	479	552	839	575	284	122	100	157	158	174
12	356	454	448	593	921	543	262	124	97	152	158	160
13	355	433	406	601	904	508	257	120	94	155	158	154
14	379	436	388	632	928	513	252	126	89	156	158	163
15	376	434	373	667	874	554	275	126	85	154	152	176
16	386	426	373	698	889	556	267	128	91	156	149	189
17	373	429	381	718	837	593	248	125	93	157	154	192
18	359	434	374	755	807	621	238	120	95	157	159	189
19	348	430	364	804	781	599	229	117	99	156	167	197
20	356	418	333	879	723	592	205	117	100	152	173	198
21	365	415	335	944	657	554	197	120	98	148	184	209
22	347	407	348	816	611	532	189	117	97	147	182	264
23	340	395	332	777	620	520	188	111	100	147	177	268
24	357	377	323	821	638	519	184	110	99	148	188	230
25	342	392	338	996	635	488	162	107	102	149	186	213
26	347	455	355	1,108	613	411	155	104	116	151	178	214
27	350	428	348	1,233	720	423	157	93	135	151	171	217
28	337	436	341	1,237	818	420	151	97	175	145	167	214
29	342	.....	362	1,227	771	421	136	104	280	140	173	218
30	333	.....	379	995	675	405	131	110	243	133	184	212
31	325	.....	383	.....	612	.....	131	115	.....	132	.....	205
Mean	363	434	388	710	735	551	244	120	116	160	166	199

1899.

1	196	289	303	678	759	929	859	235	100	92	186	220
2	195	300	305	621	712	1,009	856	229	101	93	189	216
3	224	307	314	612	652	944	857	208	101	90	185	209
4	240	288	320	604	633	964	811	207	103	94	185	204
5	214	279	306	624	649	1,007	776	196	105	95	190	211
6	212	275	304	700	659	1,066	763	191	108	95	100	212
7	208	274	309	768	682	1,361	719	196	115	97	196	219
8	213	264	308	855	680	1,560	679	190	115	95	191	216
9	229	264	313	925	623	1,631	622	186	108	109	190	209
10	253	274	311	1,014	588	1,770	563	184	103	111	188	214
11	308	276	299	988	649	1,926	516	173	101	114	204	203
12	346	273	272	926	850	2,072	499	170	98	126	220	196
13	300	277	267	953	1,102	1,994	280	163	105	152	213	218
14	284	281	258	968	1,258	1,756	468	155	110	180	212	220
15	277	293	253	1,010	1,225	1,568	450	150	110	191	330	224
16	281	299	261	1,049	1,051	1,550	439	147	113	194	211	267
17	285	301	262	1,132	959	1,570	446	147	113	189	236	681
18	292	300	268	1,098	913	1,550	389	142	115	193	240	514
19	296	306	264	1,070	890	1,561	360	135	109	209	233	390
20	286	325	283	1,042	852	1,514	363	135	106	219	230	324
21	278	340	319	1,037	809	1,367	349	132	103	220	239	296
22	269	359	323	1,091	794	1,218	338	130	100	222	270	302
23	276	361	323	1,114	806	1,160	312	131	96	223	278	303
24	281	359	398	1,104	907	1,149	295	132	97	226	261	316
25	282	340	2,927	972	970	1,135	289	123	100	212	238	300
26	275	324	3,115	884	923	1,082	292	119	104	198	236	303
27	266	310	1,605	771	863	948	309	114	110	187	228	293
28	269	310	1,105	951	819	848	290	108	109	183	223	280
29	274	.....	877	709	822	846	266	106	98	183	222	289
30	274	.....	797	718	885	863	255	106	93	188	222	284
31	280	.....	722	.....	803	.....	239	102	.....	189	.....	318
Mean	263	302	590	893	835	1,331	489	156	105	160	221	278

MOHAVE RIVER AT VICTOR, CALIFORNIA.

The headwaters of this river have their source on the northern slope of the Sierra Madre and flow northerly, finally disappearing in the sands of the Mohave Desert. At Victor, a station on the Atchison, Topeka and Santa Fe Railroad, the river passes through a narrow gorge, locally known as The Narrows. This place has been under investigation as a possible dam site, and soundings for the depth of bed rock were made by the United States Geological Survey during the season of 1899. The greatest depth of bed rock was found to be 54 feet. The diamond drill showed the rock to be a fine granite. A more detailed account of this exploration will be given in the Twenty-first Annual Report, Part IV. Above The Narrows the valley broadens into a large reservoir site, but as no surveys of it have been made the capacity is unknown. In order to determine the amount of water available for storage for this reservoir, a gaging station was established February 27, 1899. The rod is a 2 by 6 inch timber, bolted to a vertical cliff on right bank of the river, 600 feet upstream from wagon bridge. The bench mark is top of east rail of the Santa Fe track, 75 feet south of center of wagon bridge over track. The zero mark of rod is 12.84 feet below bench mark. The following measurements of discharge were made under the direction of J. B. Lippincott during 1899:

February 27, gage height, 1 foot; discharge, 44 second-feet.
May 5, gage height, 0.90 foot; discharge, 32 second-feet.
June 13, gage height, 0.90 foot; discharge, 25 second-feet.
July 26, gage height, 0.85 foot; discharge, 22 second-feet.

Rating table for Mohave River at Victor, California, 1899.

Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*
0.80	17	1.00	44
0.85	22	1.10	60
0.90	28		

Daily gage height, in feet, of Mohave River at Victor, California, for 1899.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	1.00	1.10	1.00	1.00	0.90	0.90	0.85	0.85	0.90	0.90
2	.....	1.00	1.10	1.00	.90	.90	.85	.85	.85	.90	.90
3	.....	1.00	1.00	.90	1.00	.90	.85	.85	.85	.90	.90
4	.....	1.00	1.00	.90	.90	.90	.85	.85	.85	.90	.90
5	.....	1.00	1.00	.90	.90	.90	.85	.85	.85	.90	.90
6	.....	1.00	.90	.90	.90	.90	.85	.85	.85	.90	.90
7	.....	.90	1.00	1.00	.90	.90	.85	.85	.85	.85	.90
8	.....	.90	1.00	1.00	.90	.90	.85	.85	.85	.85	.90
9	.....	1.00	.90	1.00	.90	.90	.90	.85	.85	.85	.90
10	.....	1.00	1.00	.90	.90	.90	.90	.85	.85	.85	.90
11	.....	1.00	1.00	.90	.90	.90	.90	.85	.90	.85	.90
12	.....	1.00	1.00	.90	.90	.90	.90	.85	.80	.85	.90
13	.....	.90	.90	1.00	.90	.90	.85	.85	.85	.90	.90
14	.....	.90	1.00	1.00	.90	.90	.85	.85	.85	1.00	.....
15	.....	.90	1.00	1.00	.90	.90	.85	.85	.85	.90	.....
16	.....	1.00	.90	1.00	.90	.90	.85	.85	.85	.90	.....
17	.....	1.00	.90	.90	.90	.90	.90	.85	.85	.90	.....
18	.....	1.10	1.00	1.00	.90	.90	.90	.85	.85	.90	.....
19	.....	.90	1.00	1.00	.90	.90	.80	.85	.85	.90	.....
20	.....	.90	1.00	1.00	.90	.90	.85	.85	.85	.90	.....
21	.....	1.10	1.00	1.00	.90	.90	.85	.85	.85	.90	.....
22	.....	1.00	.90	1.00	.90	.90	.85	.85	.85	.90	.....
23	.....	1.00	1.00	1.00	.90	.90	.85	.85	.85	.90	.....
24	.....	1.00	1.00	1.00	.90	.90	.85	.85	.85	.90	.....
25	.....	1.00	1.00	1.00	.90	.90	.85	.85	.85	.90	.....
26	.....	1.00	1.00	.90	.90	.85	.90	.85	.85	.90	.....
27	1.00	.90	.90	.90	.90	.85	.90	.85	.90	.90	.....
28	1.00	1.00	1.00	.90	.90	.85	.85	.85	.90	.90	.....
29	.....	1.00	1.00	1.00	.90	.85	.85	.85	.90	.90	.....
30	.....	.90	1.00	1.00	.90	.85	.85	.85	.90	.90	.....
31	.....	1.00	.....	1.00	.....	.85	.85	.....	.90	.....	.....

No record December 14 to 31.

LOS ANGELES RIVER AT THE NARROWS, CALIFORNIA.

his river heads immediately south of Santa Clara River, its various utaries receiving their water supply from the mountains surround- the San Fernando plains. The river passes out of the lower of the valley through a short gorge known as The Narrows, at lower end of which is located the city of Los Angeles. The ams entering San Fernando Valley have in the past brought n immense quantities of sand and gravel from the mountainous , and have thus formed the San Fernando plains. This coarse osit acts as a natural reservoir, absorbing the floods, the water dually appearing lower down. The rainfall of southern California been deficient for the last few years, but the discharge of Los geles River at The Narrows has been exceptionally constant; in 9 the decrease in discharge being not more than 10 per cent of the rage. A study of the river has been made by J. B. Lippincott the city of Los Angeles. The flow is of marked constancy, and s believed that the measurements indicate with fair accuracy discharge for the respective months. As in previous reports, discharge measurements for 1899 include the flow of the river bridge No. 2, the main supply ditch at a point opposite, and Glassell tributary. In addition water is diverted for irrigation poses from a point known as Formans Lake to the vicinity of bank; and also from the development works of the West Los

Angeles Water Company, to the south side of Cahuenga Mountains. Results of measurements for 1896 and to April, 1899, inclusive, may be found in the Twentieth Annual Report, Part IV, page 542. The following measurements of discharge were made by J. B. Lippincott during 1899:

Discharge measurements of Los Angeles River at The Narrows, California.

1899.

Date.	Discharge.	Date.	Discharge.
	Second-feet.		*Second-feet.*
January 5	67	August 25	59
February 14	61	September 20	53
February 25	67	September 27	54
March 11	63	October 25	57
March 25	61	October 31	58
April 29	52	November 17	59
May 18	58	November 28	56
June 7	56	December 13	58
July 18	55	December 26	58
August 19	57		

ARROYO SECO, CALIFORNIA.

This is a small basin draining 21 square miles of the Sierra Madre. The river issues from the mountains on the west side of Pasadena Mesa, passes through an opening in a granite spur known as Devils Gate, and joins Los Angeles River at Los Angeles. Between the point where the water issues from the mountain and Devils Gate lies a broad river bottom 2 miles in length and composed of coarse material. In passing over this the water sinks rapidly, diminishing in volume from the mouth of the canyon to Devils Gate. The following measurements were made at the cable station at the terminal quarries by E. P. Dewey and W. B. Clapp in 1899:

Discharge measurements made on Arroyo Seco, California.

1899.

Date.	Discharge.	Date.	Discharge.
	Second-feet.		*Second-feet.*
January 10	3.02	March 20	2.52
January 11	1.90	March 21	1.90
January 12	2.00	March 22	1.64
January 12	2.06	March 23	1.56
February 1	.24	March 26	2.20
March 17	3.24	March 28	1.22
March 18	1.77	April 2	.28
March 19	.93	April 12	.07

SAN GABRIEL RIVER ABOVE AZUSA, CALIFORNIA.

The drainage basin of this river lies on the southern slope of the Sierra Madre, the watershed being included in Los Angeles County, California. The various tributaries join the river before it enters its lowest canyon, whence it appears finally on the plain in the vicinity of

Azusa. The seepage waters of this valley appear lower down in the river and finally enter the Pacific Ocean not far from the mouth of Los Angeles River. All of the surplus waters of this stream are now used for irrigation purposes. Owing to the numerous diversions, it has been difficult to obtain accurate discharge measurements; but during 1898 the San Gabriel Electric Company completed its system, and measurements are now obtained with greater ease and hence with greater accuracy. The headworks of this company are located about 3 miles above the mouth of the canyon; the water is carried along the left side by a series of tunnels and conduits, and a head of 400 feet is obtained where the electric power is generated. Weirs are placed on the conduit of the electric company, and the water is measured at this point. The capacity of the conduit is 90 second-feet. The season of 1899 was notable in southern California for the deficiency of rainfall, and on six days only was there a surplus of water flowing past the gaging station. The following are the dates, with their respective discharges, on which water passed the gaging station in 1899:

January 11, gage height, 1.18 feet; discharge, 16 second-feet.
January 12, gage height, 1.08 feet; discharge, 12 second-feet.
January 13, gage height, 0.90 foot; discharge, 6 second-feet.
January 14, gage height, 0.78 foot; discharge, 2 second-feet.
January 15, gage height, 0.70 foot; discharge, 1 second-foot.
October 14, gage height, 1.10 feet; discharge, 13 second-feet.

From these measurements the following rating table was constructed:

Rating table for San Gabriel River above Azusa, California, 1899.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.40	0.0	1.00	9	1.60	38
0.50	0.2	1.10	13	1.70	45
0.60	0.5	1.20	17	1.80	53
0.70	1.2	1.30	21	1.90	63
0.80	3.0	1.40	26	2.00	80
0.90	6.0	1.50	31	.....	.....

During the rest of the year the entire flow passed through the electric company's canal. The gaging station on the main river is located at the mouth of the canyon. The equipment consists of a rod, cable, car, and tagged wire. Results of measurements may be found as follows: 1896, Eighteenth Annual Report, Part IV, page 405; 1897, Nineteenth Annual Report, Part IV, page 528; 1898, Twentieth Annual Report, Part IV, page 550. The first of the following tables shows the dates in 1898 at which there was water in the main river, together with the amount of discharge. The next table shows the combined discharge for 1898 of the canals diverting water at the mouth of the canyon. A part of this table, from September to December, inclusive, was published in Water-Supply Paper No. 28, page 190; but the data for

the previous portion of the year having now been obtained, the entire table is here given. Dates in 1899 on which there was water passing the gaging station on the main river are given above. Following the table of canal discharges for 1898 is a table showing the daily discharge of San Gabriel canals for 1899. The total flow of the river is obtained by adding the daily discharge for the river to the figures, for the corresponding dates, for the canals.

Daily discharge, in second-feet, of San Gabriel River above Azusa, California, for 1898.

Day.	Jan.	Feb.	Mar.	Apr.	May.	Day.	Jan.	Feb.	Mar.	Apr.	May.
1	0.0	8.0	0.0	0.0	0.0	17	19.0	31.0	0.0	0.0	11.0
2	0.0	9.0	0.0	0.0	0.0	18	17.0	11.0	0.0	0.0	9.0
3	0.0	9.0	0.0	0.0	0.0	19	17.0	11.0	0.0	0.0	9.0
4	0.0	9.0	0.0	0.0	0.0	20	17.0	11.0	0.0	0.0	9.0
5	0.0	0.2	0.0	0.0	13.0	21	17.0	11.0	0.0	0.0	0.0
6	0.0	0.2	0.0	0.0	0.0	22	17.0	11.0	0.0	0.0	0.0
7	0.0	0.2	0.0	0.0	0.0	23	15.0	9.0	0.0	0.0	0.0
8	0.0	41.0	0.0	0.0	0.0	24	15.0	0.0	0.0	0.0	0.0
9	26.0	31.0	0.0	0.0	0.0	25	15.0	0.0	0.0	0.0	0.0
10	31.0	26.0	1.0	0.0	0.0	26	15.0	0.0	0.0	0.0	0.0
11	26.0	21.0	0.0	0.0	0.0	27	15.0	0.0	0.0	0.0	0.0
12	24.0	15.0	0.0	0.0	0.0	28	15.0	0.0	0.0	0.0	0.0
13	24.0	13.0	0.0	0.0	0.0	29	15.0	.....	0.0	0.0	0.0
14	24.0	11.0	0.0	0.0	0.0	30	15.0	.....	0.0	0.0	0.0
15	21.0	9.0	0.0	0.0	63.0	31	9.0	.....	0.0	.....	0.0
16	21.0	31.0	0.0	0.0	24.0						

River dry June 1 to December 31.

Daily discharge, in second-feet, of the San Gabriel canals above Azusa, California, for 1898.

[Drainage area, 222 square miles.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	28.0	28.0	33.0	36.5	26.0	30.0	14.5	9.5	8.2	9.0	9.0	11.7
2	28.0	28.0	32.0	37.0	39.0	28.0	13.0	9.5	10.0	9.8	8.5	11.8
3	28.0	28.0	31.0	37.0	37.0	25.0	13.5	9.5	8.2	10.0	8.5	11.8
4	28.0	28.0	31.0	37.0	36.0	23.5	13.0	9.0	8.2	10.5	8.0	11.9
5	27.0	32.0	31.0	37.5	34.0	22.8	13.0	9.0	8.2	9.0	8.5	11.9
6	27.0	32.0	31.0	36.5	31.5	21.0	12.0	9.0	8.2	9.0	9.0	11.9
7	27.0	32.0	30.0	36.0	32.0	20.2	14.0	8.5	7.9	8.5	9.0	12.0
8	27.0	29.0	30.0	35.0	31.0	20.0	12.5	8.5	7.9	8.5	9.0	12.0
9	32.0	29.0	28.0	35.0	30.0	20.0	11.5	8.5	8.0	8.5	8.5	12.0
10	32.0	29.0	34.0	35.0	28.0	21.5	11.5	8.4	8.0	9.0	8.7	12.2
11	31.0	29.0	34.0	34.0	25.0	23.5	11.0	8.5	7.5	8.7	9.0	12.5
12	25.0	32.0	32.5	32.5	25.0	22.0	11.0	8.5	7.5	8.0	9.8	12.6
13	25.0	32.0	34.0	32.5	25.0	21.4	10.0	8.4	7.5	8.0	9.8	12.6
14	25.0	32.0	33.5	32.5	25.5	21.0	10.0	6.5	7.5	7.5	9.2	12.6
15	25.0	32.0	33.5	34.0	20.0	20.2	9.7	7.0	7.0	7.5	9.8	18.2
16	25.0	10.0	36.0	34.0	27.5	18.0	10.0	7.0	7.0	7.5	9.8	15.2
17	25.0	10.0	36.0	34.0	45.5	17.5	9.7	7.0	6.7	8.0	9.8	15.0
18	25.0	29.0	37.0	34.0	40.0	16.2	10.0	7.0	6.5	8.0	9.0	15.0
19	25.0	29.0	37.0	33.0	38.5	15.2	10.0	5.0	6.5	8.4	10.1	14.4
20	25.0	29.0	37.0	33.0	33.5	17.0	10.0	5.5	6.1	8.6	10.5	14.5
21	25.0	29.0	37.0	32.0	37.0	16.0	11.5	6.0	7.5	7.9	10.5	14.5
22	24.0	29.0	36.0	30.0	36.0	17.0	11.5	6.0	7.5	8.2	10.5	14.5
23	24.0	29.0	34.0	29.0	35.0	17.3	11.5	6.0	7.5	9.0	11.2	14.5
24	23.0	34.0	34.0	27.0	32.5	17.0	9.5	6.0	7.5	10.0	11.2	14.5
25	23.0	34.0	34.0	26.0	30.5	16.0	9.5	5.5	8.5	9.0	10.5	14.8
26	23.0	34.0	48.0	25.3	30.0	16.0	9.0	5.5	8.5	9.1	10.5	14.0
27	23.0	34.0	41.0	25.3	30.0	16.0	9.0	6.3	7.5	9.1	10.5	14.0
28	23.0	34.0	39.0	27.0	30.5	15.8	9.0	7.5	10.2	8.9	11.0	14.0
29	23.0	.....	36.0	30.0	29.5	15.0	9.5	7.0	8.0	8.9	11.5	14.5
30	23.0	.....	36.0	35.5	30.5	14.5	9.5	7.0	10.2	8.4	11.5	14.0
31	28.0	.....	37.0	.....	30.0	.....	9.5	7.0	.....	8.4	.....	14.0
Mean	25.9	29.1	34.6	32.8	31.7	19.5	10.9	7.4	7.9	8.7	9.8	13.5

Daily discharge, in second-feet, of the San Gabriel canals above Azusa, California, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	14.8	27.2	20.3	28.0	17.5	22.2	4.0	5.0	3.4	3.7	12.0	16.2
2	24.2	28.0	20.3	27.5	17.5	20.0	4.0	5.1	3.0	4.0	11.5	16.0
3	20.3	26.2	21.5	25.2	17.0	17.0	4.0	5.5	4.0	4.0	11.5	16.0
4	19.0	24.2	19.4	24.8	17.0	15.0	4.0	5.5	4.3	4.0	11.7	16.0
5	19.0	23.5	18.7	24.8	15.5	14.8	4.0	6.0	3.7	4.0	10.1	16.3
6	18.0	23.5	18.5	25.0	17.5	13.5	4.2	6.0	4.3	4.0	10.2	16.0
7	18.0	23.5	18.0	24.0	17.5	12.0	4.2	5.0	3.7	4.3	10.2	16.0
8	18.0	23.5	18.5	22.2	16.5	11.0	3.5	4.7	4.5	3.7	10.2	15.7
9	18.0	23.4	18.7	22.0	15.5	9.7	3.4	4.7	5.5	3.7	10.3	15.5
10	22.0	23.4	18.7	23.5	14.0	8.5	3.4	4.5	5.0	4.4	12.0	15.5
11	33.0	23.4	19.0	23.5	13.0	8.8	3.5	4.7	4.0	8.5	12.0	15.5
12	32.0	23.4	19.0	22.2	13.0	9.0	3.4	4.5	4.0	9.0	12.0	15.5
13	22.0	23.0	19.0	21.0	12.5	9.5	3.0	4.5	3.6	22.0	12.0	15.5
14	22.0	21.8	19.0	21.0	12.0	9.2	3.4	4.3	3.8	22.0	14.5	15.5
15	22.0	21.6	19.0	20.5	12.5	8.0	3.5	4.0	4.2	26.0	15.0	16.0
16	22.0	20.3	31.2	20.0	14.1	7.8	3.5	4.0	4.0	19.0	15.0	23.0
17	18.0	20.0	36.4	19.7	13.0	7.5	3.3	4.5	3.7	16.0	15.0	39.0
18	18.0	20.0	35.0	19.5	13.0	7.5	3.0	6.0	3.7	15.0	14.0	30.0
19	19.7	19.7	29.0	19.5	13.5	7.3	3.0	6.0	3.7	13.5	14.0	28.0
20	19.3	19.7	39.5	18.5	11.5	7.0	3.0	6.0	3.7	13.5	14.0	25.0
21	20.4	19.7	37.4	17.0	11.5	7.0	3.0	5.5	3.3	13.0	16.0	23.0
22	21.6	19.7	32.7	16.5	11.5	6.2	3.3	5.5	3.3	13.5	23.5	22.5
23	22.8	20.3	31.7	16.2	11.5	6.2	3.5	5.0	3.3	14.0	20.0	21.5
24	23.6	22.4	32.5	17.5	12.0	6.2	3.5	4.0	3.0	14.0	18.3	20.7
25	24.0	21.8	35.5	19.3	12.0	6.2	3.5	4.0	3.0	12.5	18.0	20.7
26	24.0	21.2	35.4	21.0	12.0	6.2	4.0	4.0	3.0	12.0	17.2	20.7
27	24.1	21.2	32.0	21.3	11.5	6.0	4.0	4.0	3.3	12.0	17.0	20.7
28	23.5	21.0	32.0	20.5	11.5	5.5	4.0	5.5	3.3	12.3	17.0	21.0
29	23.2	.....	31.6	18.0	12.7	5.5	4.0	4.0	3.3	11.5	16.7	23.0
30	24.2	.....	30.0	17.5	12.0	4.9	4.0	4.0	3.7	13.0	16.3	23.0
31	26.2	.....	29.5	.....	13.5	.....	4.0	4.0	.....	12.3	.....	22.0
Mean	21.8	22.4	26.4	21.2	13.7	9.5	3.6	4.8	3.7	11.1	14.2	20.3

LYTLE CREEK AT MOUTH OF CANYON, CALIFORNIA.

This small stream drains the southern slope of the Sierra Madre and discharges its waters onto the plains northwest of San Bernardino. Although it drains a comparatively small area of 54 square miles, at the mouth of the canyon its waters are important for irrigation purposes. Owing to the controversies which have arisen over its diversions, a number of lawsuits for the settlement of the claims have been instituted from time to time. A number of measurements of this stream at the mouth of the canyon from 1892 to 1896, inclusive, are given below. They are copied from court records of proceedings in which the water supply of this creek was involved. These cases were tried in the San Bernardino courts by Judge A. W. McKinley. The measurements were made by A. H. Koebig and G. O. Newman, on weirs, and are believed to be accurate.

Discharge measurements of Lytle Creek at mouth of canyon, California.

Date.	Discharge.	Date.	Discharge.
1892.	*Second-feet.*	1894.	*Second-feet.*
June 3	35.58	August 19	11.44
September 20	18.70	August 25	12.32
September 30	22.04	October 3	16.20
October 28	20.64	1895.	
November 21	22.04	September 2	56.10
November 27	20.68	September 30	40.78
1893.		1896.	
September 7	49.20	March 3	18.08
September 18	49.20	April 23	19.14
September 25	46.34	April 24	18.60
October 4	45.30	April 25	20.52
1894.		May 3	18.32
June 6	17.96	May 4	17.26
June 8	15.50	May 10	18.16
July 10	13.22	May 25	15.32
July 11	13.22	May 26	12.84
July 25	13.36		

Beginning in 1894, measurements of Lytle Creek were also made by H. D. Sibley, who was zanjero of the Lytle Creek canals at that time. The measurements were usually made because the discharge of the stream was below normal. In the winter and spring only the amount of water needed for irrigation was turned into the ditches, but later in the summer the entire flow was diverted. These measurements also were made over weirs, and are believed to be fairly accurate. During 1898 trouble was experienced by miners taking the water from the natural channel and turning it into dry channels, sluice boxes, weirs, mill races, etc., thereby causing a loss of from 20 to 25 per cent of the total flow of the creek. Only a portion of these latter diversions were returned to the creek. The measurements of Mr. Sibley would not show the full flow of Lytle Creek at all times, and sometimes show less than the full discharge, for the reasons mentioned above. During 1899 the amount of water which was diverted into the main canal was measured daily by the Anglo-American Canaigre Company, at a weir erected near the head of its cement ditch. The volumes given have been occasionally checked by visiting the canal and making meter measurements. It is believed that during 1899 practically all of the water of the stream was diverted into the canal.

charge, in second-feet, of Lytle Creek main canal above Rialto, California.

1894.

[Drainage area, 54 square miles.]

Day.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
			15.5					
		24.1	17.2		10.9		13.5	
	16.1			10.8				
		22.6						
			14.1				11.4	14.5
	19.9				10.8	13.0		
								13.7
	17.8	18.5	14.3	10.8			13.7	
	21.8			13.4				
			14.3			13.2		
	22.6		14.4					
		19.1						
			15.0		13.7	11.5	14.5	
	22.6			14.1				
			14.8	12.7				
	24.9				11.9	12.7		12.9
			14.6					
		18.2	14.9					
	25.4						14.2	
			15.0					
		16.6						
								12.5
				11.7	13.4			

1895.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
			54.4						
							36.9		
			68.0			51.4			
								30.5	
		33.9					31.5		
						48.8			
								24.9	
						50.8			
									22.0
					50.4				
						44.8			
	26.4	43.8					41.9		
		57.5					36.5		
							34.1	24.0	
	37.4				52.5				
						47.1			
					54.4				
						36.5	34.5		
							34.5		

June 5 to August 16 ditch broken, no measurements.

Discharge, in second-feet, of Lytle Creek main canal above Rialto, California—Continued.

1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1					17.8				13.2			
2				22.2		14.1	11.1					
3												
4												
5	20.0									12.2		
6						11.4			12.2			
7								11.5				
8		19.2					11.1					
9						13.5				11.6		16.0
10						12.5			12.2			
11												
12						11.9		10.5				
13		18.4										
14						12.2	12.2					16.0
15				24.9								
16	21.4				17.1			13.7	10.8			17.0
17			19.8									
18				19.7				11.3				
19									11.8			
20							10.5					
21								12.0				
22												16.0
23								12.5		11.1		
24				22.4				12.5				
25											28.0	
26									11.8	20.0		
27							10.7					
28								13.5				
29		17.5										
30					15.0							24.0
31												

Heavy rains March 1 to 5 and October 26; all water turned out of canal.

1897.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1								
2								
3		60.0						
4					36.0			
5								
6			60.0					
7		24.0						
8								
9				50.0	30.0			
10	16.0							
11								
12								10.0
13								
14			60.0					
15								
16	24.0				34.0			
17								
18		80.0						
19				60.0				
20								
21		50.0						
22								
23								
24				50.0				
25	20.0		60.0					
26								
27								
28		56.0	70.0	40.0				
29	28.0							
30								
31								

Heavy rains February 3 and 18, March 28, September 14. Chicala Water Company took charge of station June 1.

arge, in second-feet, of Lytle Creek main canal above Rialto, California—Continued.

1898.

y.	May.	June.	July.	Day.	May.	June.	July.	Day.	May.	June.	July.
...	.....	.....	10.9	12....	.....	.....	.....	22....	.....	11.7	.....
...	.....	.....	.....	13....	.....	.....	.....	23....	.....	.....	.....
...	.....	.....	.....	41....	.....	.....	.....	24....	.....	.....	.....
...	.....	.....	.....	15....	.....	13.9	.....	25....	.....	.....	.....
...	.....	.....	.....	16....	.....	.....	.....	26....	.....	.....	.....
...	.....	.....	.....	17....	.....	.....	.....	27....	.....	.....	.....
...	.....	.....	.....	18....	.....	.....	.....	28....	14.6	09.0	.....
...	.....	.....	.....	19....	.....	.....	.....	29....	.....	.....	.....
...	.....	.....	.....	20....	.....	11.5	.....	30....	.....	.....	.....
...	.....	.....	.....	21....	.....	.....	.....	31....	.....	.....	.....
...	.....	.....	.....								

No measurements for January to April, inclusive, and August to December, inclusive.

1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	11.1	11.8	11.2	9.7	11.2	12.2	6.3	9.4	14.5	10.9	10.5	11.1
.....	11.1	12.1	11.1	8.9	10.9	10.4	6.8	10.4	15.1	10.8	10.3	11.3
.....	12.1	12.1	11.2	8.5	10.9	9.7	6.4	9.6	16.6	10.8	10.3	11.4
.....	11.4	12.4	11.1	12.6	10.5	9.5	6.4	10.7	16.7	10.8	10.6	11.1
.....	11.7	12.4	10.8	12.5	10.5	9.4	6.4	12.2	16.0	10.7	10.5	11.3
.....	11.6	12.5	10.6	12.1	10.5	9.6	6.4	11.0	16.0	10.6	10.6	11.3
.....	11.6	12.6	10.4	11.9	10.5	9.2	6.3	10.8	16.0	10.1	10.6	11.3
.....	11.6	12.4	10.4	11.8	10.2	9.0	6.2	11.0	15.9	9.9	9.9	11.6
.....	11.6	12.1	10.9	11.7	11.8	.....	6.2	11.0	16.5	10.2	9.9	11.4
.....	12.0	11.8	10.6	11.9	9.5	7.2	6.0	8.7	16.1	10.8	10.0	11.5
.....	16.1	11.8	10.6	11.7	9.5	7.5	5.9	12.0	16.0	11.7	10.2	11.4
.....	13.1	11.8	10.6	11.7	9.2	8.2	6.0	12.0	15.8	72.1*a*	10.5	11.3
.....	12.2	11.8	10.7	11.0	9.6	8.1	5.9	12.2	15.3	12.4	10.9	11.2
.....	12.0	11.6	10.7	10.6	9.5	7.8	5.9	12.1	15.4	13.5	11.0	11.1
.....	11.9	11.5	10.7	10.6	9.8	.....	6.0	12.3	16.0	12.7	11.3	11.2
.....	12.0	11.5	15.3	10.7	9.4	7.6	6.0	12.3	15.5	13.0	11.7	12.9
.....	12.0	11.5	14.7	10.6	9.4	7.8	5.8	12.2	15.3	13.0	11.5	11.8
.....	12.0	11.3	13.7	10.7	9.4	7.9	5.4	12.6	14.3	12.3	12.0	11.8
.....	11.9	11.4	12.3	10.2	9.7	7.7	5.6	13.0	15.7	12.0	11.9	11.6
.....	11.8	11.3	13.7	10.8	9.8	7.3	5.6	13.0	14.9	11.4	11.8	11.6
.....	11.7	11.3	13.1	9.9	9.5	7.5	5.8	12.5	15.2	11.2	12.2	11.3
.....	11.8	11.3	12.9	9.9	9.4	7.6	7.2	12.4	16.1	11.6	12.7	11.1
.....	11.7	11.3	12.8	10.3	9.4	7.4	8.6	12.4	10.8	11.9	12.1	11.1
.....	11.6	11.8	13.2	10.6	9.2	7.1	9.3	12.5	10.4	10.3	12.0	11.1
.....	11.6	11.4	14.8	10.5	9.2	7.2	8.9	12.4	10.3	10.7	13.8	10.9
.....	11.6	11.4	13.5	10.4	9.0	7.4	9.2	12.6	10.3	11.4	11.7	11.2
.....	11.6	11.3	13.4	10.4	9.0	7.3	9.4	12.5	10.5	11.3	11.5	11.1
.....	11.6	11.3	13.6	10.4	9.0	7.2	9.5	12.2	10.5	11.1	11.5	11.1
.....	11.6	.....	13.6	11.0	9.4	6.7	9.7	12.3	10.6	11.0	11.4	11.2
.....	11.6	.....	13.5	11.2	9.3	6.4	9.6	12.2	10.6	11.4	11.2	11.1
.....	11.7	.....	13.5	.....	.....	.....	10.0	12.1	.....	11.3	.....	11.3
Mean.....	11.9	11.7	12.2	10.8	9.8	8.1	7.1	11.8	14.3	13.3	11.2	11.3

a Rain in mountains.

SANTA ANA RIVER AT WARMSPRINGS, CALIFORNIA.

This river has its source on the southern slope of the San Bernardino Mountains and flows southerly, appearing from its canyon 4 miles north of Redlands. Its waters are completely used in San Bernardino Valley. At the lower part of the valley the water appears again in the vicinity of Rincon, where the river passes through a comparatively narrow gorge, and the general direction of the stream is thence southwesterly, emptying into the Pacific Ocean. The station, established June, 1896, is located 5 miles northeast of Mentone, California, three-fourths of a mile below the headworks of the Santa Ana canal and opposite the warm springs in the canyon. The gage is an inclined timber fastened to a large bowlder and posts set in the bank of the river. On October 16, 1898, owing to some local legal complications, an unusually large volume of water was turned into the Santa Ana canal by the Bear Valley Company. This water was wasted from the canal at a point below the old gage rod, necessitating the establishment of a new gage rod upon this stream at a point below where the waste from the canal was turned into the river. The new gage was put in November 9, 1898, and since that date daily observations have been kept on the lower gage, which is a 2 by 6 inch timber firmly bolted to a granite cliff which forms the left bank of the river, and is situated 800 feet below the mouth of Warmsprings Canyon and 100 feet above a ford on the canyon road. A landslide occurred below the gage rod April 16, 1899, which changed the condition of the rating for the station. Owing to the shifting nature of the stream bed it has not been possible to construct perfectly satisfactory rating curves, but the tables as presented are based on the best information that could be obtained. The record is not considered absolutely correct, but is given as an approximation. This river is one of the most difficult streams in the State of which to obtain an accurate record. The Edison Electric Company diverts the greater portion of the water of Santa Ana River above the gaging station, but also returns all of it above the station; they, however, allow only limited portions of the water to pass out of their conduits during certain hours of the day, holding back the water for the purpose of obtaining additional power when the greatest demand exists. An effort is being made to arrange with this company to obtain a record of the number of gates, the sizes of the openings, and the hours at which the various wheels are run, in order to more accurately determine the volumes of water. The Santa Ana canal, as mentioned above, also diverts water from Santa Ana River above the station, but the greater part of it is returned to the channel of the stream before passing the point of measurement. A portion, as indicated by the measurements *below*, passes down the canal. Results of measurements may be found *as follows*: 1896, Eighteenth Annual Report, Part IV, page 411; 1898,

Twentieth Annual Report, Part IV, page 554. A number of measurements of discharge of the canals diverting water from Santa Ana River at the mouth of the canyon were made by S. G. Bennett, and are given below. The following measurements were made at the main station under the direction of J. B. Lippincott in 1899:

Discharge measurements of Santa Ana River at Warmsprings, California.

1899.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
	Feet.	*Second-feet.*		*Feet.*	*Second-feet.*
January 12	2.34	38.00	May 31	2.27	21.00
February 18	2.16	28.04	June 15	2.21	19.60
March 23	2.30	29.62	July 15	2.30	25.90
May 6	2.45	25.84	August 24	1.85	10.86

Rating table for Santa Ana River at Warmsprings, California, applicable from January 1 to April 15, 1899.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.8	12.5	2.1	21.5	2.3	34.0
1.9	15.0	2.2	26.5	2.4	48.0
2.0	18.0				

Rating table for Santa Ana River at Warmsprings, California, applicable from April 16 to December 31, 1899.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.7	8.0	2.2	19.0	2.7	36.0
1.8	10.0	2.3	22.0	2.8	41.0
1.9	12.0	2.4	25.0	2.9	46.5
2.0	14.0	2.5	28.5	3.0	52.5
2.1	16.5	2.6	32.0		

Discharge measurements of Santa Ana canal, California.

1899.

Date.	Discharge.	Date.	Discharge.
	Second-feet.		*Second-feet.*
January 12	.....	May 31	1.10
February 18	4.00	June 15	.20
March 23	7.60	July 15	.....
May 6	3.40	August 24	.....

Discharge measurements of canals diverting water from Santa Ana River at mouth of canyon, California.

Date.	Canal.	Discharge.
1899.		*Second-feet.*
February 18	North Fork or Highland ditch	8.07
February 18	South Fork or Redlands ditch	15.70
February 18	Green Spot pipe line	.35
March 23	North Fork or Highland ditch	11.78
March 23	South Fork or Redlands ditch	17
March 23	Green Spot pipe line	3.71
May 6	North Fork or Highland ditch	7.70
May 6	South Fork or Redlands ditch	15.50
May 6	Green Spot pipe line	1.43
May 31	North Fork or Highland ditch	6.74
May 31	South Fork or Redlands ditch	14.67
May 31	Green Spot pipe line	.14
June 15	North Fork or Highland ditch	10.30
June 15	Morton Canyon water	.17
June 15	Redlands tunnel water at point where it reaches South Fork ditch.	.67
June 15	South Fork or Redlands ditch at flume above sand box.	7.76
June 15	Head of Green Spot pipe line	.08
July 12	South Fork or Redlands ditch	11.50
July 15	North Fork or Highland ditch	13.14
July 15	Morton Canyon water	.12
July 15	Redlands tunnel	1.03
July 15	South Fork or Redlands ditch	12.70
July 15	Head of Green Spot pipe line.	.59

Daily gage height, in feet, of Santa Ana River at Warmsprings, California, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.10	2.20	2.20	2.30	2.35	2.65	2.30	2.20	1.90	1.90	2.20	2.35
2	2.10	2.25	2.20	2.20	2.30	2.35	2.30	2.20	1.90	1.90	2.20	2.24
3	2.10	2.25	2.20	2.15	2.30	2.40	2.30	2.20	1.90	1.90	2.20	2.24
4	2.10	2.25	2.20	2.20	2.35	2.35	2.30	2.00	1.90	1.90	2.20	2.26
5	2.10	2.20	2.20	2.20	2.40	2.30	2.30	2.00	1.90	1.90	2.11	2.20
6	2.10	2.20	2.20	2.20	2.45	2.30	2.35	2.00	1.90	1.90	2.12	2.17
7	2.10	2.20	2.20	2.20	2.45	2.30	2.35	1.90	1.90	2.00	2.15	2.18
8	2.10	2.20	2.20	2.20	2.35	2.30	2.35	1.90	1.90	1.95	2.16	2.15
9	2.10	2.20	2.20	2.15	2.25	2.30	2.35	1.90	1.90	1.95	2.15	2.22
10	2.10	2.20	2.20	2.15	2.25	2.25	2.37	1.90	1.90	1.90	2.15	2.25
11	2.30	2.20	2.20	2.15	2.30	2.25	2.37	1.90	1.90	1.90	2.15	2.26
12	2.30	2.20	2.20	2.15	2.30	2.25	2.35	1.90	1.90	1.90	2.12	2.25
13	2.30	2.20	2.15	2.15	2.35	2.30	2.35	1.90	1.96	2.20	2.17	2.25
14	2.30	2.20	2.15	2.10	2.35	2.30	2.35	1.90	1.90	2.20	2.15	2.25
15	2.20	2.20	2.15	2.10	2.30	2.30	2.30	1.90	1.90	2.15	2.61	2.25
16	2.20	2.20	2.20	2.40	2.30	2.25	2.30	1.90	1.90	2.15	2.19	2.25
17	2.20	2.20	2.25	2.35	2.30	2.30	2.30	1.90	1.90	2.15	2.30	2.53
18	2.20	2.20	2.35	2.35	2.25	2.30	2.30	1.90	1.80	2.15	2.44	2.47
19	2.20	2.20	2.30	2.35	2.25	2.20	2.30	1.90	1.80	2.17	2.24	2.48
20	2.20	2.20	2.55	2.30	2.25	2.30	2.25	1.87	1.80	2.17	2.29	2.44
21	2.20	2.20	2.55	2.30	2.30	2.30	2.20	1.87	1.80	2.17	2.26	2.37
22	2.20	2.20	2.30	2.30	2.20	2.25	2.25	1.87	1.80	2.17	2.95	2.42
23	2.20	2.20	2.30	2.30	2.25	2.25	2.25	1.87	1.85	2.17	2.51	2.71
24	2.20	2.30	2.35	2.35	2.30	2.25	2.25	1.87	1.85	2.17	2.24	2.64
25	2.20	2.20	2.35	2.40	2.30	2.30	2.50	1.90	1.85	2.20	2.30	2.22
26	2.20	2.25	2.35	2.40	2.30	2.35	2.50	1.90	1.90	2.20	2.26	2.34
27	2.20	2.20	2.40	2.40	2.25	2.30	2.30	1.90	1.90	2.20	2.33	2.36
28	2.20	2.20	2.35	2.40	2.30	2.30	2.27	1.90	1.90	2.20	2.25	2.40
29	2.20	.....	2.35	2.40	2.30	2.28	2.25	1.90	1.90	2.20	2.25	2.32
30	2.20	.....	2.35	2.35	2.30	2.28	2.20	1.90	1.90	2.20	2.25	2.34
31	2.20	.....	2.30	.....	2.30	.....	2.20	1.90	.....	2.20	.....	2.37

MILL CREEK IN CANYON, CALIFORNIA.

This stream is one of the larger tributaries of Santa Ana River, although on account of its importance for irrigation it is generally considered as an independent stream. It rises on the western slope of the San Bernardino Mountains, draining the area immediately south of the headwaters of Santa Ana River. Mill Creek appears from its canyon about 5 miles east of Redlands. The Crafton Water Company diverts all of the water of this creek at the mouth of the canyon, particularly in the summer. The water passes over a weir, and the volume is therefore determined with considerable accuracy. The records have been furnished to this office by Mr. Herbert Garstine, president of the Crafton Water Company. They are particularly accurate for low-water measurements. This stream is described in detail in the Nineteenth Annual Report, Part IV, page 551. The first table gives the measurements made by S. G. Bennett near the head of Crafton zanja in 1899. The second table shows the discharge of Mill Creek, as furnished by the Crafton Water Company, at the head of Crafton zanja during the irrigation seasons of 1897, 1898, and 1899.

Discharge measurements near head of Crafton zanja, California.

1899.

Date.	Discharge.	Date.	Discharge.
	Second-feet.		*Second-feet.*
January 12	10.77	May 31	11.61
February 18	10.53	June 15	6.94
March 23	15.63	July 15	7.40
May 6	14.55	August 24	7.18

Discharge, in second-feet, of Mill Creek at head of Crafton zanja, California.

1897.

Day.	July.	Aug.	Sept.	Oct.	Day.	July.	Aug.	Sept.	Oct.	Day.	July.	Aug.	Sept.	Oct.
1	.....	21	22	18	12	24	20	18	16	22	.....	22	27	.....
2	.....	23	22	18	13	24	20	18	15	23	.....	21	19	.....
3	.....	24	22	19	14	.....	20	18	15	24	.....	21	16	.....
4	.....	24	21	19	15	.....	20	18	18	25	.....	22	19	.....
5	.....	24	20	17	16	.....	19	19	18	26	28	21	19	.....
6	.....	21	20	21	17	.....	19	16	18	27	22	21	18	.....
7	.....	22	19	19	18	.....	24	17	18	28	27	20	18	.....
8	.....	22	19	19	19	.....	26	18	20	29	27	20	19	.....
9	.....	22	18	19	20	.....	24	19	18	30	24	20	19	.....
10	.....	19	18	18	21	.....	24	20	18	31	24	20	.....	.....
11	.....	19	18	16										

Discharge, in second-feet, of Mill Creek at land of Crafton ranch, California—Continued.

1898.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	17	26	16	11	8	9	9	10	10
2	.....	17	22	16	10	8	9	9	10	10
3	.....	17	17	16	10	8	7	9	10	10
4	.....	17	17	16	11	8	9	9	10	10
5	.....	17	16	16	11	8	8	9	10	10
6	.....	17	17	14	11	7	9	9	10	10
7	.....	17	17	12	11	7	8	9	10	10
8	.....	17	17	14	10	7	8	9	10	10
9	.....	17	17	14	10	7	8	9	10	10
10	.....	17	15	15	8	a 10	8	9	10	11
11	.....	16	15	14	8	10	8	9	10	11
12	.....	17	15	14	10	8	7	9	10	11
13	.....	17	15	14	10	8	8	9	10	11
14	.....	18	15	13	10	7	8	9	10	11
15	.....	18	18	13	9	7	8	9	10	12
16	.....	17	18	13	9	7	7	9	10	11
17	.....	17	18	12	9	7	8	9	10	12
18	.....	17	18	15	8	7	8	9	10	11
19	.....	17	20	12	9	7	8	9	10	11
20	.....	17	18	12	9	11	8	9	10	11
21	17	17	17	13	9	25	8	9	10	11
22	.....	17	16	12	9	17	8	9	10	11
23	.....	17	16	13	9	14	8	9	10	10
24	.....	17	18	12	8	10	8	8	10	10
25	18	16	16	12	7	10	9	9	10	11
26	18	16	16	11	9	9	9	8	10	11
27	17	15	18	11	7	9	9	9	10	10
28	17	16	18	11	7	13	9	9	10	11
29	17	19	17	10	7	13	8	9	10	11
30	17	19	16	10	8	11	9	10	10	11
31	17	.....	16	.....	7	11	.....	10	.....	11

a Not entire flow of creek.

1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	11	11	11	13	12	17	5.6	7.1	5.5	4.8	7.2	9.8
2	11	11	11	13	11	13	6.2	6.2	5.6	5.3	7.2	9.8
3	11	11	11	12	11	12	6.2	5.8	5.4	5.3	6.8	9.4
4	11	11	11	12	11	11	6.2	6.7	5.4	4.3	6.8	8.8
5	11	11	11	12	11	10	4.9	7.2	5.5	4.6	7.2	8.0
6	12	11	11	11	11	11	6.7	6.9	5.6	6.3	7.2	7.8
7	11	11	11	12	12	10	6.7	6.7	5.6	5.6	7.2	8.0
8	10	11	11	12	12	10	6.7	6.2	5.3	4.8	7.2	8.3
9	11	12	11	12	12	10	6.7	6.2	5.7	5.6	6.1	9.0
10	.....	12	.....	12	12	8	6.2	6.2	5.3	5.2	6.1	8.8
11	.....	12	10	12	12	8	6.2	6.2	5.3	5.7	6.8	9.0
12	.....	12	10	11	12	8	6.2	6.2	4.9	6.1	6.8	8.2
13	.....	.....	10	11	12	8	4.8	5.6	4.9	6.2	6.4	9.8
14	.....	12	10	11	11	7	4.8	5.3	4.9	8.5	11.2	9.6
15	.....	12	10	11	12	7	5.1	6.2	5.2	7.8	11.2	9.6
16	.....	12	10	12	12	8	7.2	5.6	4.8	7.8	9.8	7.8
17	.....	.....	13	12	12	9	6.3	5.3	3.2	7.8	9.8	14.6
18	.....	12	13	13	11	8	4.9	6.0	3.0	7.2	9.8	13.0
19	.....	12	11	12	11	8	6.2	6.0	3.0	7.8	9.8	12.6
20	.....	12	15	11	11	8	4.9	5.3	2.8	7.2	9.7	9.8
21	.....	.....	14	11	11	8	5.1	5.9	2.8	7.2	9.7	9.4
22	.....	11	12	12	11	8	5.8	5.9	2.8	7.2	9.6	11.0
23	.....	11	12	11	11	7	6.2	5.3	2.8	7.8	9.7	9.6
24	.....	13	16	12	10	7	6.5	5.2	2.8	6.6	9.8	9.8
25	.....	11	16	12	10	7	5.4	5.3	2.8	6.6	10.4	9.8
26	.....	12	16	12	10	8	5.4	5.3	2.8	7.8	10.0	10.0
27	.....	12	12	12	11	8	4.8	5.8	2.9	7.2	9.8	10.0
28	.....	11	12	12	10	7	4.8	4.3	2.0	7.2	9.8	8.5
29	.....	.....	16	12	11	6	5.5	4.3	2.7	7.2	9.8	9.4
30	.....	.....	16	12	11	4	5.5	5.3	2.8	7.2	9.8	9.8
31	.....	.....	14	.....	11	.....	5.5	2.9	.....	7.2	.....	10.0

DEVELOPED WATER OF SAN BERNARDINO VALLEY, CALIFORNIA.

The streams of the eastern end of San Bernardino Valley are discharged from their mountain canyons on a delta-like formation of gravel and sand, into which the water rapidly sinks. Apparently a dike of impervious material extends across this valley in a northwest-southeast direction, passing a short distance east of the town of Colton. Into this body of undergound water numerous development works have been projected, and it is this source of supply which furnishes water for irrigation, particularly in the neighborhood of Riverside. Observations were instituted in 1898 to determine the total output from this underground source, and results may be found in the Twentieth Annual Report, Part IV, pages 557 and 559. Similar observations were made for the Geological Survey by Mr. K. Sanborn, in March, June, and August, 1899, in order to discover whether there is a difference in output at the end of the rainy season as compared with the end of the dry season, and whether the supply is increasing or decreasing. The following table gives the three series of measurements in 1899:

Discharge measurements in San Bernardino Valley, California.

Date.	Stream.	Ditch.	Discharge.
1899.			*Second-feet.*
February 28	Warm Creek	Upper canal, Riverside Water Company, at head gate.	60.53
Do	do	Swamp, at first turnout	.85
Do	Santa Ana River	Mill flume, Riverside Water Company, end of flume.	5.30
March 1	Lytle Creek	Whitings, head	.76
Do	do	McIntyre, head	.82
Do	City Creek	Whitlock, flume at Waterman avenue.	.47
Do	do	Logsdon & Farrell, at head	1.61
Do	do	Daley, at head	.71
Do	Warm Creek	Meeks & Daley, at head gate	17.00
March 2	do	Haws & Talmage, at head gate	.28
Do	do	Beam, flume at head	.72
Do	do	Rabel, at head gate	2.26
Do	do	Shay or Stout dam, at head gate.	2.23
Do	do	McKenzie, 300 feet below head gate.	9.40
March 7	Santa Ana River	Gage canal, head	.72
Do	do	Gage canal, Palm avenue, weir	27.40
Do	do	Timber, at head	.00
Do	Artesian wells	Camp Carlton	2.13
March 10	Santa Ana River	Lower canal, Riverside Water Company, Spanishtown ditch turnout.	16.00
Do	do	Ward & Warren, at head	3.09
Do	Artesian wells	Wells, Riverside Water Company.	16.57
March 13	Lytle Creek	Ranchero, near head	1.64

Discharge measurements in San Bernardino Valley, California—Continued.

Date.	Stream.	Ditch.	Discharge.
1899.			*Second-feet.*
March 13	Pumping plants	East Riverside irrigation district, at reservoir.	4.25
Do	do	Colton Terrace Water Company, head of pipe line.	1.69
Do	do	City of Colton	.00
Do	do	Pomeroy & Marble	.00
Do	do	Johnson & Hubbard	.00
Do	do	Base line and Waterman avenue.	.00
March 25	City Creek	In canyon above all diversions.	8.80
June 16	Warm Creek	Haws & Talmage, 300 feet below head.	.05
Do	do	Rabel, weir at head	1.54
Do	do	Shay or Stout dam, weir at head submerged.	1.13
Do	do	McKenzie, 150 feet below head gate.	3.86
June 20	do	Swamp, weir first turnout	.77
Do	Santa Ana River	Gage canal, weir at head	.24
Do	do	Gage canal, Palm avenue, weir.	25.46
Do	do	Timber, head	.00
Do	do	Ward & Warren, weir at head.	.62
Do	do	Camp Carlton, weir at head	1.62
June 23	Lytle Creek	McIntyre, weir at head	.15
Do	Pumping plants	East Riverside irrigation district, weir to reservoir.	2.08
Do	do	Upper Bloomington, submerged weir near head.	3.34
Do	do	Lower Bloomington, submerged weir flume.	5.93
June 26	Warm Creek	Meeks & Daley, weir at head	15.48
Do	do	Upper canal, Riverside Water Company, weir at head.	53.92
Do	Santa Ana River	Mill flume, Riverside Water Company, flume at mill.	7.29
Do	Pumping plants	Colton Terrace Water Company, head of pipe line.	1.30
Do	do	City of Colton, weir, upper plant.	2.09
Do	do	City of Colton, estimated	2.60
Do	do	Mill pump, Riverside Water Company, weir at mill.	1.77
June 27	Warm Creek	Beam, flume at head	.52
Do	Lytle Creek	Whitings, weir at head	.26
Do	City Creek	Whitlock, flume, Stiles street	.28
Do	do	Logsdon & Farrell, flume at head.	1.15
Do	do	Daley, flume across City Creek	.51
June 28	Santa Ana River	Lower canal, Riverside Water Company, flume at head.	9.09
August 22	Warm Creek	McKenzie, 200 feet below head gate.	2.00
August 25	do	Haws & Talmage, head gate	.00
Do	do	Rabel, at head gate	.94
Do	do	Shay or Stout dam, weir at head.	.90
Do	do	Meeks & Daley, weir at head	10.45
Do	Santa Ana River	Gage canal, weir at head	.64
Do	do	Gage canal, Palm avenue, weir.	24.11
Do	do	Timber, head	.00

Discharge measurements in San Bernardino Valley, California—Continued.

Date.	Stream.	Ditch.	Discharge.
1899.			*Second-feet.*
August 26	Warm Creek	Beam, flume at head	.40
Do	Lytle Creek	McIntyre, head	.00
Do	do	Whitings, head	.01
Do	do	Ranchero, weir near head	.41
Do	Pumping plants	East Riverside irrigation district, pumps not running.	.00
Do	do	Colton Terrace Water Company	1.30
Do	do	City of Colton, upper pumps	1.52
Do	do	City of Colton, lower pumps	2.37
Do	do	Upper Bloomington, weir at head.	1.18
Do	do	Lower Bloomington, weir at flume.	3.05
Do	do	Pomeroy & Marble, not running.	.00
Do	do	Johnson & Hubbard, not running.	.00
Do	do	Base line and Waterman avenue, estimated by owner.	1.20
August 27	Santa Ana River	Camp Carlton, weir at head	1.02
August 28	City Creek	Whitlock, flume, Stiles street	.09
Do	do	Logsdon & Farrell, flume at head.	.54
Do	do	Daley, flume across City Creek	.51
August 30	Warm Creek	Swamp, weir first turnout	.69
Do	Santa Ana River	Ward & Warren, weir at head	1.56
Do	do	Mill flume, Riverside Water Company, flume at mill.	2.50
August 31	Pumping plants	Mill pump, Riverside Water Company, weir at pump.	1.67
Do	Warm Creek	Upper canal, Riverside Water Company, weir at head.	52.04
September 1	Santa Ana River	Lower canal, Riverside Water Company, flume at head.	7.38

TEMESCAL CREEK NEAR RINCON, CALIFORNIA.

This stream rises in the extreme southwestern corner of Riverside County, California. Its smaller tributaries have their sources on the eastern slope of the Santa Ana Mountains. The river flows in a general northerly direction, entering Santa Ana River 2½ miles above Rincon and just above the lower narrows of the Santa Ana. San Jacinto River discharges into Lake Elsinore. During years of heavy rainfall this lake overflows and the surplus water finds its way into Temescal Creek. During the last few years, however, there has been no such discharge from Lake Elsinore. The water of Temescal Creek and of its tributary, Coldwater Creek, is used for irrigation in the vicinity of Corona. A series of measurements of Temescal and Coldwater creeks have been made by F. Rolfe, and are given below. The first table gives the measurements at the upper pipe line of the Temescal Land and Water Company at the manhole in Rolfe's field; the second table shows the discharge of the lower pipe line at Eddy's blacksmith shop; the third table is the discharge of the same pipe line near

Riley's ranch; the fourth table shows the discharge of Coldwater Creek at its mouth.

During the recent dry years there has been no surface flow of Temescal Creek. The water flowing in the upper pipe line of the Temescal Land and Water Company includes the principal part of the flow of Coldwater Creek and Temescal Hot Springs, augmented by water pumped from wells in Temescal Valley.

Discharge measurements of upper pipe line of Temescal Land and Water Company at manhole in Rolfe's field, California.

1899.

Date.	Discharge.	Date.	Discharge.
	Second-feet.		*Second-feet.*
January 27	0.74	April 22	3.71
February 4	1.62	April 29	3.25
February 11	.87	May 6	2.80
February 18	3.67	May 13	4.02
February 24	3.37	May 18	4.21
March 3	3.87	May 30	4.01
March 12	5.10	June 9	3.36
March 16	3.56	June 16	3.53
March 25	3.74	July 10	3.21
March 31	4.16	July 19	3.20
April 14	2.93	July 25	3.67

Discharge measurements of lower pipe line of Temescal Land and Water Company, California.

1899.

Date.	Discharge.	Date.	Discharge.
	Second-feet.		*Second-feet.*
January 28	0.66 *a*	April 22	2.28 *a*
February 1	.00 *a*	April 29	2.28 *a*
February 11	.34 *a*	May 6	1.46 *a*
February 15	1.39 *a*	May 13	2.55 *a*
February 20	1.56 *a*	May 30	3.08 *b*
March 4	4.22 *a*	June 9	3.10 *b*
March 12	3.51 *a*	June 15	2.36 *b*
March 18	2.69 *a*	July 4	2.87 *b*
March 25	2.91 *a*	July 19	2.03 *b*
March 31	3.42 *a*	July 28	2.49 *b*
April 14	.89 *a*		

a Measurements at Eddy's blacksmith shop. *b* Measurements near Riley's ranch.

Discharge measurements of Coldwater Creek at mouth, California.

1899.

Date.	Discharge.	Date.	Discharge.
	Second-feet.		*Second-feet.*
January 18	1.43	April 15	0.62
January 27	.84	April 21	.26
February 3	.99	April 26	.38
February 11	.97	May 5	.37
February 18	.78	May 13	.21
February 24	.94	May 17	.21
March 1	.92	May 29	.27
March 12	.71	May 31	.38
March 17	1.60	May 31	.30
March 25	1.18	June 5	.20
March 31	.84	June 7	.22
April 14	.68		

CHINO CREEK AT RINCON, CALIFORNIA.

San Antonio Creek discharges from the southern slope of the Sierra Madre onto a large bed of sand and gravel. The underground waters percolate slowly to the south, and begin to appear again in the channel of what is known as Chino Creek. This creek enters Santa Ana River just before the latter stream passes through its lower canyon in the Coast Range. The discharge of Chino Creek is very constant, owing to the nature of its supply, and hence water rights along its course are valuable on account of their permanency. A series of measurements of the supply of this creek were made during 1899 under the direction of J. B. Lippincott. There is no gage rod, owing to the shifting nature of the stream bed.

Discharge measurements of Chino Creek at Rincon, California.

1899.

Date.	Discharge.	Date.	Discharge.
	Second-feet.		*Second-feet.*
May 2	12.79	August 15	2.14
May 15	8.64	August 31	3.19
June 3	17.02	September 29	3.38
June 15	5.63	October 25	14.52
July 4	3.02	October 26	14.52
July 17	4.68	November 18	20.06
August 1	7.49		

SANTA ANA RIVER AT RINCON, CALIFORNIA.

This river and its tributaries derive their water supply from the southern and western slopes of the San Bernardino Mountains. On their appearance from their canyons the water is shortly diverted for irrigation purposes. After passing through San Bernardino Valley water begins to appear on the lower courses of Santa Ana River, and at the point where it passes through the Coast Range a remarkably constant stream is found. The bed rock, although not visible in the channel of the river, must be near the surface, judging by the appearance of the water in the bed. Springs of large volume occur on the southern side of the river near Rincon, and the flat lands immediately above there are heavily saturated with the rising water. Artesian water also is found in considerable quantities from Rincon to Pomona, in the valley of Chino Creek. Twelve miles above Rincon Santa Ana River passes through what is known as Riverside Narrows, and here also the water appears at the surface. Approximately 80 second-feet are used in this locality for irrigation purposes. Two measurements were made at Riverside Narrows in 1899, the first, on July 17, showing a discharge of 31.70 second-feet, and the second, on September 12, showing a dis-

charge of 39.69 second-feet. Measurements were also made during 1899 of Santa Ana River at the Rincon Narrows. The first were made 1 mile below the town of Rincon, and included the water of Chino Creek. After September 29 measurements were made at the bridges in the town of Rincon and above the mouth of Chino Creek. It was found that at this latter point from 2 to 3 second-feet more water was flowing than at the locality 1 mile below, where the earlier measurements were made.

Discharge measurements of Santa Ana River near Rincon, below mouth of Chino Creek, California.

Date.	Discharge in second-feet.		
	River.	Canal.	Total.
1898.			
June 21	79.81	3.18	82.99
August 28	62.67	4.15	66.82
1899.			
January 3	209.40	2.30	211.70
January 16	231.90	.....	231.90
January 28	216.00	6.50	222.50
February 15	181.00	1.75	182.75
March 4	108.60	0.00	108.60
March 18	199.89	0.00	199.89
April 6	172.23	0.00	172.23
April 18	101.10	2.75	103.85
May 2	100.34	2.45	102.79
May 15	100.36	3.95	104.31
June 3	110.27	3.18	113.45
June 16	87.89	1.65	89.54
July 4	68.89	2.42	71.31
July 18	64.13	1.54	65.67
August 1	57.82	3.44	61.26
August 15	64.71	3.16	67.87
August 30	65.90	2.00	67.90
September 13	72.73	1.65	74.38
September 29	83.82	.....	83.82

Discharge measurements of Santa Ana River at Rincon, above mouth of Chino Creek, California.

1899.

Date.	Discharge in second-feet.			
	River.	Chino Creek.	Springs.	Total.
October 25	131.32	14.52	0.50	146.34
October 26	146.53	14.52	.50	161.55
November 18	151.16	20.06	.50	171.72

SAN LUIS REY RIVER, CALIFORNIA.

This river rises on the western slope of the Coast Range, in the northern part of San Diego County, California. It flows westerly, with rapid fall, and after passing through a narrow gap in the mountains finally enters the Pacific about 35 miles north of San Diego. The water of this river is diverted upon its appearance from the canyon by the flume of the Escondido irrigation district, and is conducted to a reservoir, whence its waters are used for irrigation purposes. In

ddition to this diversion, 2 second-feet, approximately, are permitted o remain in the river for the use of the Indians near Pauma, who are rior appropriators. The following results are furnished by the 'scondido irrigation district. The measurements are made over a reir at the headworks of their canal. The following table shows the ntire flow of the river, with the exception of the 2 second-feet noted bove. The drainage area at the point of diversion is 229 square iiles.

Discharge, in second-feet, of San Luis Rey River in canyon, California, for 1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.0	3.0	5.6	10.9	a	10.0	a	a	a	a	0.0	0.0
2	0.0	20.0	5.3	9.3	.....	10.0	.....	.....	.....	.....	0.0	0.0
3	0.0	33.0	5.0	9.0	.....	0.0	.....	.....	.....	.....	0.0	0.0
4	0.0	13.3	4.7	8.6	.....	0.0	.....	.....	.....	.....	0.0	0.0
5	0.0	14.9	4.1	8.1	.....	0.0	.....	.....	.....	.....	0.0	0.0
6	0.0	10.1	3.6	7.8	.....	0.0	.....	.....	.....	.....	0.0	0.0
7	0.0	10.2	3.6	7.3	.....	0.0	.....	.....	.....	.....	0.0	0.0
8	0.0	10.2	3.6	6.5	.....	0.0	.....	.....	.....	.....	0.0	0.0
9	0.0	9.3	3.6	6.2	.....	0.0	.....	.....	.....	.....	0.0	0.0
10	0.0	9.0	3.6	5.9	.....	0.0	.....	.....	.....	.....	0.0	0.0
11	24.0	8.6	3.6	5.3	.....	0.0	.....	.....	.....	.....	0.0	0.0
12	0.0	7.8	3.6	4.9	.....	0.0	.....	.....	.....	.....	0.0	0.0
13	0.0	7.8	3.6	4.6	.....	0.0	.....	.....	.....	.....	0.0	0.0
14	10.0	7.8	3.6	4.4	.....	0.0	.....	.....	.....	.....	0.0	0.0
15	0.0	7.8	3.6	4.1	.....	0.0	.....	.....	.....	.....	0.0	0.0
16	6.0	7.3	3.6	3.9	.....	0.0	.....	.....	.....	.....	0.0	2.0
17	6.0	6.9	24.4	3.6	.....	0.0	.....	.....	.....	.....	0.0	0.0
18	6.0	5.9	24.4	0.0	.....	0.0	.....	.....	.....	.....	0.0	4.8
19	5.6	5.6	11.7	0.0	.....	0.0	.....	.....	.....	.....	0.0	3.6
20	5.3	5.3	11.7	0.0	.....	0.0	.....	.....	.....	.....	0.0	0.0
21	4.9	4.9	25.0	0.0	.....	0.0	.....	.....	.....	.....	0.0	0.0
22	4.7	4.7	18.5	0.0	.....	0.0	.....	.....	.....	.....	0.0	0.0
23	3.0	4.7	13.3	0.0	.....	0.0	.....	.....	.....	.....	3.0	0.0
24	3.6	16.8	11.7	0.0	.....	0.0	.....	.....	.....	.....	0.0	0.0
25	3.6	10.1	10.9	0.0	.....	0.0	.....	.....	.....	.....	0.0	2.6
26	3.6	7.5	19.5	4.7	.....	0.0	.....	.....	.....	.....	0.0	0.0
27	3.4	6.6	11.7	4.1	.....	0.0	.....	.....	.....	.....	0.0	0.0
28	3.0	5.9	10.9	0.0	.....	0.0	.....	.....	.....	.....	0.0	0.0
29	3.0	.....	17.8	0.0	.....	0.0	.....	.....	.....	.....	0.0	0.0
30	3.0	.....	15.1	0.0	.....	0.0	.....	.....	.....	.....	0.0	7.2
31	3.0	.....	11.7	.....	.....	.....	.....	.....	.....	.....	.....	5.4

a River dry for month.

SWEETWATER RIVER AT SWEETWATER DAM, CALIFORNIA.

This river has its source on the western slope of the Cuyamaca Mountains, in the extreme southern part of San Diego County, Cali-'ornia, adjoining Mexico. During the last three seasons observations of the discharge of this river into the Sweetwater reservoir have been nade by N. H. Savage, who is the chief engineer of the Sweetwater rrigation system. The measurements are of particular accuracy, ecause the capacity of the reservoir is definitely known, and the read-ngs of the gage rod in the reservoir indicate volumes discharged. Mr. Savage furnishes these records voluntarily, and they are of special nterest, not only because of the great value of water in this portion of San Diego County, but also because this basin is located in the extreme outhwestern corner of the United States. The effects of the severe rought of the last few years in southern California are brought out

very plainly by a study of the discharge table which is given below. The drainage area above the reservoir is 186 square miles. The second table shows the amount of evaporation, by weeks, from the water surface of the Sweetwater reservoir, from January 1, 1897, to April 30, 1899. The third table shows the rainfall for 1898.

Estimated discharge of Sweetwater River at Sweetwater dam, California.

[Drainage area, 186 square miles.]

Year.	Discharge.	Total for year.	Run-off.		Rain.
	Sec. feet.	*Acre-feet.*	*Inches.*	*Sec. feet.*	
1896-97	9.35	6,777	0.665	0.050	10.27
1897-98	.006	4.3	.0005	.000032	7.05
1898-99	.339	245.5	.025	.0018	5.05

Evaporation at Sweetwater dam, California.

1897.

Date.	Weekly.	Monthly.	Date.	Weekly.	Monthly.
	Inches.	*Inches.*		*Inches.*	*Inches.*
January 1 to June 30		25.177	October 10	1.312	
July 4	.773		October 17	1.066	
	1.031		October 24	.984	
July 11	1.722		October 31	1.312	
July 18	1.724		November 7	.902	5.272
July 25	1.968		November 14	1.025	
August 1	1.617	8.062	November 21	1.148	
	.269		November 28	.920	
August 8	1.886		December 5	.234	4.229
August 15	1.845			.586	
August 22	1.783		December 12	.574	
August 29	1.722		December 19	.492	
September 5	.492	7.997	December 26	.492	
	1.230		December 31	.631	2.775
September 12	1.640				
September 19	1.476		Total for 1897		40.048
September 26	1.394				
October 3	.796	6.536			
	.598				

Records for three days in August were assumed; high winds filled pan.

Evaporation at Sweetwater dam, California—Continued.

1898.

Date.	Weekly.	Monthly.	Date.	Weekly.	Monthly.
	Inches.	*Inches.*		*Inches.*	*Inches.*
January 2	a 0.631		July 10	1.722	
	.107		July 17	1.968	
January 9	.328		July 24	1.804	
January 16	.246		July 31	1.886	
January 23	.492		August 7	1.804	8.153
January 30	.574		August 14	1.804	
February 7	.41	1.747	August 21	1.886	
February 13	.574		August 28	1.804	
February 20	.82		September 4	.843	8.141
February 27	.730			1.125	
March 6	.129	2.671	September 11	1.722	
	.773		September 18	1.804	
March 13	.738		September 25	1.599	
March 20	.82		October 2	.989	7.239
March 27	1.248			.395	
April 3	.670	4.249	October 9	1.230	
	.519		October 16	1.189	
April 10	1.066		October 23	1.025	
April 17	1.148		October 30	.984	
April 24	1.353		November 6	.176	4.999
May 1	1.265	5.351		1.054	
	.211		November 13	1.066	
May 8	1.230		November 20	.820	
May 15	1.23		November 27	.738	
May 22	1.066		December 4	.334	4.012
May 29	1.394			.445	
June 5	.490	5.611	December 11	No record.	
	1.201		December 18	No record.	
June 12	1.640		December 25	No record.	
June 19	1.517		December 31	.422	.867
June 26	1.804				
July 3	1.031	7.193	Total for 1898		60.233
	.773				

a Evaporation during last five days in 1897. Record missing for three weeks in December.

1899.

January 1	a 0.422		March 12	1.23	
	.070		March 19	.902	
January 8	.828		March 26	.656	
January 15	.246		April 2	.878	4.366
January 22	.533			.352	
January 29	.820		April 9	1.148	
February 5	.165	2.162	April 16	1.230	
	.411		April 23	1.886	
February 12	.656		April 30	1.312	5.928
February 19	.802				
February 26	.820		Total for 1899, to April 30		15.426
March 5	.281	2.970			
	.703				

a Evaporation during last six days in 1898.

Rainfall at Sweetwater dam, California.

Month.	1898.	1899.	Month.	1898.	1899.
	Inches.	*Inches.*		*Inches.*	*Inches.*
January	2.33	2.40	August	0.00	.00
February	.13	.70	September	0.00	.00
March	1.50	.89	October	0.00	.41
April	.33	.23	November	0.07	1.66
May	.85	.11	December	0.76	.77
June	0.00	.58			
July	0.00	.00	Total	5.97	7.77

MISCELLANEOUS DISCHARGE MEASUREMENTS IN CALIFORNIA.

During the severe drought of 1898 measurements on the important irrigation streams of California during their low stages were instituted, and the results were shown in Water-Supply Paper No. 28, page 193. The rainfall for 1899 was also deficient throughout California, and up to the present time the water shortage has been extreme. As a continuation of the low-water measurements of the previous years the series given below were made during 1899:

Miscellaneous discharge measurements in California in 1899.

Date.	Stream.	Locality.	Discharge.
			Second-feet.
January 11	Eaton Canyon Creek	At falls	0.50
March 14	Piru Creek	Narrows, 8½ miles above Piru.	3.52
March 15	Sespe Creek	Headworks of Sespe Land and Water Company's canal.	8.25
Do	Lower Cienega ditch	In Santa Clara Valley, 1 mile east of Fillmore.	2.43
March 16	Piru Creek	Just above wagon-road crossing, 200 feet below Southern Pacific Railroad bridge.	60.60
March 17	do	do	151.50
March 24	East Twin Creek	15 feet above headworks of Del Rosa canal.	3.88
Do	West Twin Creek	At point above headworks of canal.	3.00
March 25	Plunge Creek	At point below intake in walled canal.	10.85
September 13	Sacramento River	Jellys Ferry	4,087.00
September 16	American River	1 mile above mouth of South Fork.	86.10
Do	do	North Fork ditch, at road crossing 2½ miles above Folsom.	19.64
Do	do	Natoma ditch, South Fork, at Placerville road crossing.	20.00
Do	do	South Fork, estimated by Mr. Knight, superintendent Folsom Electric Power Company.	20.00
September 15	Sutter Creek	At town of Suttercreek, estimated.	1.00
Do	Cosumne River	At bridge, Jackson and Latrobe road crossing.	2.00
Do	do	Ditch, south side, at bridge, Jackson and Latrobe road crossing.	2.00
September 14	Mokelumne River	100 feet below bridge, Mock Hill, Jackson road.	63.10
Do	Calaveras River	Bridge, San Andres and Jackson road.	0.00
September 9	Stanislaus River	Oakdale	88.40
September 11	Tuolumne River	1,000 feet below gaging station, at bridge, Lagrange.	12.10
Do	do	Turlock canal, flume No. 3	28.00
Do	do	Mining ditch	24.00
		Total	65.00

Miscellaneous discharge measurements in California in 1899—Continued.

Date.	Stream.	Locality.	Discharge.
			Second-feet.
September 11	Merced River	Hoffman canal, 300 feet below head gate.	16.50
Do	do	1 mile above head gate, Hoffman canal.	35.50
Do	do	Valley Mills ditch	4.95
		Total	56.95
Do	do	Snellings ditch, estimated	0.50
September 8	San Joaquin River	Pollasky, 500 feet above bridge.	269.30
Do	do	Herndon	195.60
September 4	Kings River	Red Mountain	206.00
Do	do	Church ditch, at check weir just below Trimmer Springs road crossing.	151.10
Do	do	Fowler Switch canal, near mouth of canyon.	0.00
Do	do	Kingsburg canal, near mouth of canyon, estimated.	0.25
Do	do	Enterprise canal, near mouth of canyon, estimated.	2.00
Do	do	'76 canal, near mouth of canyon.	0.00
September 6	Kaweah River	Kaweah Irrigation and Power Company canal. This water is being pumped from wells.	1.49
Do	do	Pogues ditch	4.87
Do	do	One-half mile above headworks of Kaweah Irrigation and Power Company canal.	40.92
Do	do	North Fork	1.12
Do	do	South Fork, Britton ditch	0.41
Do	do	South Fork, estimated, Buttmann & Hitchcock ditch.	0.20
Do	do	South Fork, Carter's lower ditch.	0.32
Do	do	South Fork, estimated, Carter's upper ditch.	0.25
Do	do	At iron bridge	33.30
September 5	Tule River	Pioneer canal, just below headworks.	13.12
Do	do	Pioneer canal at road crossing, 1 mile below head gate.	8.43
Do	do	Pioneer canal at bridge road crossing, 2 miles below head gate.	7.06
September 2	Poso Creek		0.00
Do	Kern River	First point of measurement	99.22
September 5	Deer Creek		0.00
September 19	Santa Clara River	East channel, point where road crosses below San Francisquito Creek.	3.38
Do	do	West channel, below San Francisquito Creek.	1.65
Do	do	Newhall ditch	3.37
		Total	8.40

Miscellaneous discharge measurements in California in 1899—Continued.

Date.	Stream.	Locality.	Discharge.
			Second-feet.
August 19	Santa Clara River	Cumulos ranch ditch, 2 miles east of Cumulos ranch.	17.63
Do	do	2 miles east of Cumulos ranch house.	1.24
		Total	18.87
August 18	do	Farmers ditch	16.00
Do	do	Grease ditch	8.61
Do	do	East Side ditch	5.80
Do	do	Near Santa Paula	10.34
		Total	40.75
August 19	Piru Creek	Head of ditch of Piru Fruit Company.	1.33
August 18	Sespe Creek	In walled canal, Sespe Land and Water Company ditch.	1.93
Do	Santa Paula River	In flume 300 feet west of Nupu schoolhouse, 3 miles above Santa Paula.	0.85
August 21	Pacoima wash	Dry at mouth of canyon. Small spring from south side of mountain above wash, flowing 0.01, estimated.	0.00
Do	Pacoima submerged dam.	Pumping water which had accumulated during night. Man in charge of pump says they pump from 5 to 8 miners' inches per day.	0.24
Do	Little Tujunga River.		0.00
Do	Tujunga River	At weir headworks of Monte Vista ditch.	0.20
Do	do	Same place, statement of ditch tender.	0.44
August 28	San Gabriel River	Canals, statement H. F. Parkinson.	5.50
August 29	San Antonio Creek	Division weir, one-half to Pomona, one-half to Ontario.	4.06
Do	do	To Ontario	0.42
		Total	4.48
Do	Cucamonga Creek	Red Hill development, water goes to Ontario.	2.48
Do	Lytle Creek	Weir, head of Rialto canal	10.62
Do	do	Weir, head of Grapeland canal.	1.91
		Total	12.53
August 26	do	McIntyre ditch, at head	0.00
Do	do	Whitings ditch	0.01
Do	do	Ranchero ditch, weir near head.	0.41
August 25	Warm Creek	Haws & Talmage ditch, head gate.	0.00

Miscellaneous discharge measurements in California in 1899—Continued.

Date.	Stream.	Locality.	Discharge.
			Second-feet.
August 25	Warm Creek	Rabel ditch, head gate	0.94
Do	do	Shay or Stout ditch, weir at head.	0.90
August 22	do	McKenzie, 200 feet below head gate.	2.00
August 25	do	Meeks & Daley ditch, weir at head.	10.45
August 31	do	Upper canal, Riverside Water Company, weir at head.	52.04
August 26	do	Beam ditch, flume at head	0.40
August 30	do	Swamp ditch, weir, first turnout.	0.69
		Total of Warm Creek	67.42
August 28	City Creek	Whitlow ditch, flume, Stiles street.	0.09
Do	do	Logsdon & Farrell ditch, flume at head.	0.54
Do	do	Daley ditch, flume across City Creek.	0.51
August 25	Santa Ana River	Gage canal, weir, Santa Ana River.	0.64
Do	do	Gage canal, weir, Palm avenue.	24.11
Do	do	Timber ditch, at head	0.00
August 30	do	Ward & Warren ditch, weir at head.	1.56
Do	do	Mill flume, Riverside Water Company, flume at mill.	2.50
September 1	do	Lower canal, Riverside Water Company, flume at head.	7.38
August 27	do	Camp Carlton ditch, weir at head.	1.02
		Total	36.57
August 26	Pumping plants	East Riverside irrigation district, pumps not running.	0.00
Do	do	Colton Terrace Water Company.	1.30
Do	do	City of Colton ditch, upper pumps.	1.52
Do	do	City of Colton ditch, lower pumps.	2.37
Do	do	Upper Bloomington, weir at head.	1.18
Do	do	Lower Bloomington, weir at flume.	3.05
August 31	do	Mill pump, Riverside Water Company, weir at pump.	1.67
August 26	do	Pomeroy & Marble, not running.	0.00
Do	do	Johnson & Hubbard, not running.	0.00
Do	do	Base line and Waterman avenue, estimated by owner.	1.20
August 25	Santa Ana River	Developed and return water above Colton.	117.83
Do	Plunge Creek	In cement ditch below headworks in canyon.	0.48

Miscellaneous discharge measurements in California in 1899—Continued.

Date.	Stream.	Locality.	Discharge.
			Second-feet.
August 25	City Creek	In cement ditch near headworks in canyon.	0.17
Do	East Twin Creek	K. C. Investment Co., developed.	0.16
Do	do	Canal	0.58
Do	West Twin Creek	In V flume, at intake	0.20
August 24	Mill Creek	Old zanja	5.73
Do	do	Crafton headworks. This water is pumped from wells in bed of creek above Electric Co. power house.	1.45
		Total	7.18
Do	Santa Ana River	End of Green Spot pipe line	0.28
Do	do	South Fork ditch, Redlands canal, less amount from tunnel and Morton Canyon, 4.50 second-feet.	5.71
Do	do	Morton Canyon	0.11
Do	do	Redlands tunnel water	1.10
Do	do	Head of Green Spot pipe line	0.00
Do	do	North Fork ditch, Highlands canal, Cippoletti weir.	4.28
Do	do	Santa Ana canal	0.00
Do	do	Below overflow from Santa Ana canal.	10.86
August 30	do	Near Colton	0.00
Do	do	Submerged overflow, near Colton.	4.88
Do	do	West Riverside ditch	4.80
Do	do	Riverside Water Co., flume near Riverside Mesa tunnel.	57.39
Do	do	At Gallager Ford, just below Rubidoux Mountain.	5.63
Do	do	Chinese ditch	4.48
Do	do	At point 300 feet above Auburndale bridge, 3 miles north of Corona.	50.30
Do	do	South Side ditch	2.25
Do	do	North Side ditch	0.59
		Total at Auburndale	53.14
Do	do	1 mile below Rincon	65.90
Do	do	Scully ditch, or Bodieres, estimated.	2.00
		Total at gaging station	67.90
August 31	Chino Creek	Measured by F. Rolfe	3.19
Do	Santa Ana River	Santa Ana and Anaheim division box.	60.60
August 20	Water Canyon	Banning Colony, statement of C. D. Hamilton.	3.60
August 26	Cabazon ditch	At main road crossing	0.55
Do	Whitewater River	Two Cippoletti weirs at Bear Valley Irrigation Co. headworks.	6.34

PRECIPITATION ON MOUNTAINS IN SOUTHERN CALIFORNIA.

In order to obtain precipitation data bearing upon river discharge, a number of rain gages have been placed by Mr. J. B. Lippincott at various important points. The results obtained at these localities during 1899, together with a few figures from other sources, are shown in the following tables. The first gives the location of the rainfall station and the name of the observer, and the second the depth of rainfall, in inches, for each month of the year. Similar figures for 1896 are given on page 418 of the Eighteenth Annual Report, Part IV, for 1897 on page 539 of the Nineteenth Annual Report, Part IV, and for 1898 on page 560 of the Twentieth Annual Report, Part IV.

Location of rainfall stations in southern California.

Station.	Observer.	County.	Post-office.	Latitude.	Longitude.	Elevation.
				° ′	° ′	*Feet.*
Sisson	Southern Pacific R. R.	Siskiyou	Sisson	41 27	122 25	3,555
Redbluff	United States Weather Bureau.	Tehama	Redbluff	40 12	122 20	324
Sonora	Dr. John Shaw	Tuolumne	Sonora	38 00	120 16	1,824
Second Garrotte	J. P. Chamberlain	do	Groveland	37 49	120 12	2,900
Crockers	H. R. Crocker	do	Sequoia	37 48	119 58	4,458
Yosemite		Mariposa	Yosemite	37 45	119 35	4,063
Milo	R. T. Bailey	Tulare	Milo	36 15	118 50	3,200
Taylor's ranch	Geo. E. Carlton	Kern	Weldon	36 20	118 17	2,640
Kernville	Steven Barton	do	Isabella	35 45	118 25	2,600
Mount Breckenridge.	George Owens	do	Bakersfield	35 25	118 35	6,750
Tejon ranch	R. M. Pogsen	do	do	35 00	118 45	1,450
Fort Tejon	J. G. Stitt	do	Lebec	34 53	118 53	3,245
Bear Valley	Philip Tickert	do	Tehachapi			4,000
Glenn ranch	Jas. M. Applewhite	San Bernardino	Cajon	34 50	117 30	3,112
Frazier mine	N. Bennett	Ventura	Neenach	34 49	118 58	3,000
La Liebre	J. W. Forbes	Los Angeles	Neenach	34 46	118 40	3,170
Smith's ranch	William Smith	Ventura	Gorman	34 44	118 47	
Sneddens	Burt Snedden	do	Griffin	34 41	119 03	4,900
Mutah Flat	do	do	do	34 38	119 03	4,850
Palmdale headworks.	Burt Cole	Los Angeles	Palmdale	34 25	118 03	3,299
Magic Hill	B. L. Hutchings	do	Burbank	34 23	118 22	2,820
Holcomb Creek	Arrowhead Reservoir Co.	San Bernardino	San Bernardino	34 18	116 58	5,220
Upper Holcomb	do	do	do	34 18	116 50	7,200
Mount Sister Elsie	L. T. Rowley	Los Angeles	Monte Vista	34 17	118 14	5,021
Deep Creek	Arrowhead Reservoir Co.	San Bernardino	San Bernardino	34 17	117 05	5,200
Mount Lowe	Prof. Lewis Swift	Los Angeles	Echo Mountain	34 15	118 07	3,200
Little Bear Valley	Arrowhead Reservoir Co.	San Bernardino	San Bernardino	34 15	117 10	5,150
Follows's camp	B. W. Follows	Los Angeles	Azusa	34 14	117 49	1,800
Colby's camp	D. W. Colby	do	Pasadena			3,875
Morse's house	Arrowhead Reservoir Co.	San Bernardino	San Bernardino	34 12	117 12	5,350
Squirrel Inn	do	do	do	34 12	117 12	5,300
Mill Creek	Redlands E. L. and P. Co.	do	Redlands			5,000
Do	do	do	do			2,915
Cuyamaca	San Diego Flume Co.	San Diego	San Diego	32 58	115 35	4,800
Descanso	E. W. Hubbard	do	Descanso	32 50	116 40	3,500
Sweetwater dam	G. N. Savage	do	National City	32 43	117 00	250
Millwood	Sanger Lumber Co.	Fresno	Sanger			

Precipitation at rainfall stations in southern California, 1899.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Sisson	5.55	1.03	2.98	0.23	1.32	0.89	0.00	.....	0.00	4.01	10.83	5.67	32.51
Redbluff	9.29	0.01	6.22	0.72	.....	0.94	0.00	0.02	0.00	3.02	4.08	3.80	28.10
Sonora	6.99	0.42	14.03	1.08	2.18	2.17	0.00	0.08	0.00	6.90	7.02	5.38	46.25
SecondGarrotte	6.75	1.00	14.00	0.50	1.00	0.00	0.00	0.00	0.00	6.75	6.75	6.00	43.75
Crockers	8.32	1.00	15.89	1.50	0.15	1.65	0.00	0.00	0.00	8.10	7.45	11.38	55.54
Yosemite[a]	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Milo	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Taylor's ranch	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.78	0.66	.....
Kernville	1.95	0.19	1.89	0.28	0.25	0.45	0.00	0.00	0.00	0.78	0.85	0.73	7.37
Mount Breckenridge	1.67	0.94	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Tejon ranch	1.30	2.10	4.03	0.82	0.00	0.00	0.00	0.00	0.00	1.31	1.82	1.67	13.05
Fort Tejon	2.57	0.50	2.99	0.55	0.25	0.78	0.00	0.00	0.05	1.10	1.71	1.40	11.90
Bear Valley	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.21	1.94	.....
Frazier mine	.....	.....	.....	.....	.....	0.60	0.00	.....	.....	.....	.....	.....	.....
La Liebre	1.79	0.04	2.26	0.09	0.04	0.27	0.00	0.00	0.05	1.47	0.90	0.46	7.37
Smith's ranch	8.2	0.00	1.45	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.65	0.35	4.22
Sneddens	2.65	0.00	1.50	0.50	0.00	0.00	0.00	0.00	0.00	1.50	0.47	0.27	6.89
Mutah flat	2.25	0.00	2.50	0.50	0.00	0.00	0.00	0.00	0.00	2.00	1.30	2.25	10.80
Palmdale headworks	1.00	0.31	0.97	0.00	0.00	0.00	0.00	0.00	0.00	1.28	0.27	0.32	4.15
Magic Hill	1.60	0.15	2.07	0.14	1.55	0.05	0.00	0.00	0.07	2.25	1.07	1.20	10.15
Holcomb Creek	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Upper Holcomb	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mount Sister Elsie	2.95	0.12	3.37	0.58	0.08	0.78	0.00	0.00	0.35	2.10	1.34	0.41	12.08
Deep Creek	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mount Lowe	3.29	0.00	3.40	0.20	1.90	0.40	0.00	0.00	0.00	3.00	2.85	.....	15.04
Glenn ranch	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.96	1.00	.....
Little Bear Valley	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Follows's camp	3.59	0.84	2.49	0.12	0.00	0.91	0.00	0.00	0.12	3.03	1.64	0.44	13.18
Colby's camp	2.90	0.25	2.73	0.17	0.60	0.79	0.00	0.00	0.00	3.66	1.25	1.26	13.61
Morse's house	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Squirrel Inn	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mill Creek	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mill Creek	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cuyamaca	7.02	1.53	7.23	0.98	.....	2.96	0.04	T.	0.00	4.51	3.45	2.49	30.21
Descanso	3.49	1.69	2.73	0.25	1.45	.....	0.15	0.38	.....	.....	0.25	1.06	11.45
Sweetwater dam	2.40	0.70	0.89	0.23	0.11	0.58	0.00	0.00	0.00	0.41	1.66	0.77	7.75
Millwood	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

[a] No record.

MISCELLANEOUS DISCHARGE MEASUREMENTS IN NEBRASKA.

The following miscellaneous measurements of discharge were made in Nebraska during the year 1899:

Miscellaneous measurements of discharge in Nebraska in 1899.

Stream.	Where measured.	Date.	Discharge.	Hydrographer.
			Sec.-feet.	
Ash Creek	At mouth	May 15	0.76	C. B. Channel.
Baker Creek	North line sec. 19, T. 31 N., R. 13 W.	June 19	.35	Do.
Beaver Creek	At Hyer's, sec. 20, T. 34 N., R. 46 W.	May 22	8.97	Do.
Birdwood Creek	1 mile above mouth	May 25	183.47	H. H. Pickens.
Blue Creek	South line sec. 18, T. 17 N., R. 42 W.	May 22	90.12	Do.
Boardman Creek	At Buckley's, sec. 13, T. 30 N., R. 31 W.	June 3	16.4	C. B. Channel.
Boggy Creek	West line sec. 31, T. 33 N., R. 54 W.	May 24	.05	A. B. McCoskey.
Bone Creek	At Stringer's, sec. 16, T. 31 N., R. 21 W.	June 17	12.46	C. B. Channel.
Calamus River	Burwell	May 17	372.	Glenn E. Smith.
Do	Sec. 8, T. 24 N., R. 19 W.	Sept. 20	152.5	C. B. Channel.
Cedar Creek	Above Bruce's mill, sec. 33, T. 24 N., R. 25 W.	July 9	7.41	Do.

Miscellaneous measurements of discharge in Nebraska in 1899—Continued.

Stream.	Where measured.	Date.	Discharge.	Hydrographer.
			Sec.-feet.	
Cedar irrigation ditch.	Ericson	May 17	19.6	Glenn E. Smith.
Cedar River	Ericson, above dam	....do	107.4	Do.
Do	Ericson, below dam	....do	113.	Do.
Chadron Creek	North line sec. 36, T. 33 N., R. 49 W.	....do	8.71	C. B. Channel.
Do	Above waterworks dam, sec. 18, T. 32 N., R. 48 W.	....do	2.24	Do.
Do	Below waterworks dam	....do	2.15	Do.
Clear Creek	700 yards below Barber & Marsh head gate, sec. 32, T. 16 N., R. 41 W.	May 19	7.84	H. H. Pickens.
Do	At Schlademan's, sec. 5, T. 14 N., R. 34 W.	Dec. 16	3.4	C. B. Channel.
Cottonwood Creek.	Sec. 21, T. 35 N., R. 22 W	June 12	1.2	H. H. Pickens.
Crooked Creek	At Mutz, sec. 19, T. 34 N., R. 19 W.	June 13	1.23	C. B. Channel.
Culbertson canal	Below head gate	May 29	43.94	H. H. Pickens.
Dead Horse Creek	North line sec. 31, T. 33 N., R. 49 W.	May 17	3.46	C. B. Channel.
Do	At Slattery's ditch, sec. 32, T. 33 N., R. 49 W.	....do	3.98	Do.
Dismal River	Dunning	Apr. 21	334.48	Do.
Dry Cedar Creek	At mouth, near Ericson	May 17	5.	Glenn E. Smith.
East Ash Creek	Head of Tomlin's ditch, sec. 30, T. 32 N R. 50 W	May 15	3.35	C. B. Channel.
Do	Head of Shelton ditch, sec. 33, T. 32 N., R. 50 W.	Aug. 18	.33	A. B. McCoskey.
East Middle Creek.	Sec. 32, T. 33 N., R. 23 W	June 10	.27	C. B. Channel.
Elkhorn River	O'Neill	July 8	145.77	Do.
Frenchman River.	At Palisade, below canal	May 29	53.39	H. H. Pickens.
Do	West line sec. 5, T 5 N., R. 38 W.	June 3	29.54	Do.
Do	Maranville's, sec. 12, T. 6 N., R. 41 W.	July 8	19.33	E. D. Johnson.
Do	Below head gate of Inman's ditch	July 9	16.62	Do.
Do	At head gate of Wirsig ditch, sec. 24, T. 6 N., R. 40 W.	July 10	20.98	Do.
Do	At Palisade	Sept. 16	50.61	A. B. McCoskey.
Do	At Culbertson	....do	29.92	Do.
Do	At Wannets	Sept. 19	62.91	Do.
Goose Creek	Sec. 10, T. 22 N., R. 27 W	Apr. 27	30.27	C. B. Channel.
Holt Creek	Head of Webster & Carnahan ditch, sec. 19, T. 35 N., R. 20 W.	June 12	3.58	Do.
Horse Creek	Nebraska-Wyoming line	June 16	11.1	A. B. McCoskey.
Horsehead Creek	Sec. 16, T. 33 N., R. 24 W	June 9	1.15	C. B. Channel.
Indiana Creek	North line sec. 33, T. 32 N., R. 50 W.	Aug. 18	.5	A. B. McCoskey.
Keya Paha River	Sec. 24, T. 35 N., R. 20 W	June 13	38.99	C. B. Channel.
Little Cottonwood Creek.	West line T. 31 N., R. 51 W	May 15	.29	Do.
Do.	Below mouth of Spring Creek	May 16	.35	Do.
Lodgepole Creek	3 miles east of Sidney	May 15	10.95	H. H. Pickens.
Do	4 miles west of Kimball	Aug. 9	7.43	E. D. Johnson.
Do	1 mile west of Kimball	....do	2.41	Do.
Do	¾ mile east of Kimbal	Aug. 11	2.04	Do.
Do	¼ mile above head G. Kinney ditch, sec. 33, T 15 N. R. 56 W.	Aug. 10	6.52	Do.
Do	Above Young's head gate	....do	15.57	Do.
Long Pine Creek	Below Miller's mills, sec. 5, T. 31 N., R. 20 W.	June 15	90.67	C. B. Channel.
Middle Loup River.	Arcadia	Apr. 18	809.66	A. B. McCoskey.
Do	Dunning	Apr. 21	408.23	Do.
Do	Seneca	May 2	225.34	C. B. Channel.
Mill race	At Ericson	May 17	6.5	Glenn E. Smith.
Minichaduza River.	Valentine	Jan. 27	26.2	Do.
Do	....do	Feb. 21	45.	Do.
Do	....do	Mar. 15	25.7	Do.
Do	....do	Apr. 26	32.6	Do.
Do	....do	May 11	35.	Do.
Do	....do	May 26	64.7	Do.
Do	....do	June 26	23.	Do.
Do	....do	Aug. 13	19.	Do.
Do	....do	Sept. 13	23.5	Do.
Do	....do	Sept. 26	26.5	Do.
Hat Creek	Above Coffee's ditch, sec. 26, T. 33 N., R. 55 W.	May 24	3.6	A. B. McCoskey.
Newman Creek	Head Newman ditch, sec. 17, T. 33 N., R. 24 W.	June 9	.73	C. B. Channel.
Niobrara River	Bourette, sec. 32, T. 30 N., R. 56 W.	May 27	13.65	Do.
Do	Mouth of Whistle Creek	May 28	33.04	Do.

Miscellaneous measurements of discharge in Nebraska in 1899—Continued.

Stream.	Where measured.	Date.	Discharge.	Hydrographer.
			Sec.-feet.	
Niobrara River	Marsland	May 29	36.16	C. B. Channel.
Do	Head Hatch & Cross ditch, sec. 25, T. 29 N., R. 50 W.	....do	47.94	Do.
Do	Cook ranch, sec. 6, T. 28 N., R. 55 W.	Aug. 3	13.87	A. B. McCoskey.
Do	Curtis ranch, sec. 1, T. 28 N., R. 55 W.	Aug. 16	10.15	Do.
Do	5 miles south of Valentine	Mar. 15	650.	Glenn E. Smith.
North Fork Elkhorn River.	Norfolk	Feb. 20	119.	Do.
Do	....do	Apr. 27	122.	Do.
Do	....do	May 25	414.	Do.
Do	....do	Aug. 17	81.3	Do.
Do	....do	Sept. 25	85.2	Do.
North Loup River	Brownlee	May 1	359.79	C. B. Channel.
Do	Burwell	May 16	984.	Glenn E. Smith.
Do	Brewster	Sept. 21	361.92	C. B. Channel.
Do	Brownlee	Sept. 23	195.84	Do.
North Platte River.	Llewellen bridge	May 22	15,901.88	H. H. Pickens.
Do	Gering	June 14	16,104.8	A. B. McCoskey.
Oak Creek	3 miles northwest of Lincoln	May 10	27.46	Do.
Do	Below Eiche's, 3 miles northwest of Lincoln, after heavy rains.	July 3	703.25	Do.
Do	Dannebrog	May 19	5.	Glenn E. Smith.
Platte River	Central City (estimated)	Sept. 8	20.	Do.
Plum Creek	Sec. 35, T. 33 N., R. 23 W	June 10	81.07	C. B. Channel.
Republican River.	Above mouth of Frenchman River.	May 29	Dry.	H. H. Pickens.
Do	Orleans, below mouth of Sappa Creek.	Sept. 6	.25	Glenn E. Smith.
Do	Oxford	....do	Dry.	Do.
Do	Above Frenchman River	Sept. 19	Dry.	A. B. McCoskey.
Do	McCook	....do	12.27	Do.
Do	Head of irrigation and water-power canal, sec. 15, T. 3 N., R. 31 W.	....do	17.5	E. D. Johnson.
Sandy Creek	Sec. 3, T. 31 N., R. 15 W	June 17	8.28	C. B. Channel.
Shobe Branch	Lambs, sec. 32, T. 33 N., R. 11 W	June 20	1.66	Do.
South Platte River.	North Platte	Apr. 19	883.	Glenn E. Smith.
Do	....do	May 6	866.	Do.
Do	....do	May 22	88.	Do.
Do	....do	June 6	Dry.	Do.
Do	....do	June 19	Dry.	Do.
Do	Sutherland	May 23	50.	H. H. Pickens.
Sowbelly Creek	North line sec. 19, T. 32 N., R. 55 W.	Aug. 1	1.37	A. B. McCoskey.
Spring Creek	Head Townsend ditch, sec. 35, T. 34 N., R. 19 W.	May 16	5.18	C. B. Channel.
Do	Head Opperman's ditch, sec. 5, T. 31 N., R. 20 W.	June 15	.31	Do.
Squaw Creek	Duncan, sec. 28, T. 31 N., R. 51 W	May 11	1.21	Do.
Do	Stetsons, sec. 18, T. 31 N., R. 51 W	....do	.33	Do.
Do	Head proposed Daniel & Stetson ditch.	....do	.79	Do.
Do	Head Cooper ditch, sec. 36, T. 32 N., R. 52 W.	May 12	.72	Do.
Stinkingwater River.	Above Palisade	May 29	21.60	H. H. Pickens.
Thompson Creek	Sec. 4, T. 2 N., R. 13 W	Sept. 8	3.45	E. D. Johnson.
Trunk Butte Creek.	North line sec. 36, T. 33 N., R. 50 W	May 17	1.45	C. B. Channel.
Do	Sec. 3, T. 52 N., R. 50 W	Aug. 18	.34	A. B. McCoskey.
Turkey Creek	Sec. 30, T. 4 N., R. 21 W	Sept. 6	2.26	E. D. Johnson.
Warbonnet Creek	Brewster's ranch, sec. 21, T. 33 N., R. 56 W.	May 25	2.50	A. B. McCoskey.
West Ash Creek	At Woodwards, sec. 25, T. 32 N., R. 51 W.	May 15	.19	C. B. Channel.
West Middle Creek.	Sec. 32, T. 33 N., R. 23 W	June 2	1.48	Do.
White River	Whitney	May 15	10.37	E. D. Johnson.
Do	Below Crawford	May 17	18.68	A. B. McCoskey.
Do	Force's ranch	May 19	4.41	Do.
Do	Head Crawford ditch	...do	16.70	Do.
Do	Below Crawford	...do	18.05	Do.
Do	....do	May 22	45.89	Do.
Do	Andrews siding	May 26	4.93	C. B. Channel.
Do	Below Crawford	Aug. 19	16.20	A. B. McCoskey.
White Clay Creek	Sec. 13, T. 32 N., R. 51 W	May 11	.72	C. B. Channel.
Do	Brooks, sec. 2, T. 33 N., R. 45 W	May 20	5.27	Do.
Wooden Spring Branch.	Sec. 25, T. 35 N., R. 29 W	June 13	2.14	Do.

RATING TABLES.

e following pages contain the rating tables prepared for various stations described in Papers Nos. 35 to 39, inclusive. These the relation which has been found to exist during the year 1899 een the height of water on the gage at each locality and the dis- ge in cubic feet per second. These tables have been prepared the measurements made during 1899 or previous years, and are in computing the daily flow, the results of which are to be given ie Twenty-first Annual Report, Part IV. Taking, for example, rst table, No. 62, Delaware River at Lambertville, New Jersey, the ber 62 refers to the page upon which the river station is described. ie end of the description are given the results of discharge meas- ients made during 1899. From these and earlier data the relation ige height to discharge has been deduced and is given in the fol- ng tables. On page 63 is given the daily height in feet. On ch 1 this was 6.80. In the following table the flow equivalent to height is shown to be 33,710 second-feet. In the same manner the corresponding to each gage height in the table has been obtained the averages computed, for use, as above noted, in the annual report ing to the year 1899.

Rating tables for stations in New Jersey, Pennsylvania, Maryland, and West Vir

[Number in box head refers to page in Water-Supply and Irrigation Paper No. 35.]

Gage height in feet.	Discharge in second-feet.										
	62. Delaware River at Lambertville, New Jersey.	76. North Branch of Susquehanna River at Wilkesbarre, Pennsylvania.	77. North Branch of Susquehanna River at Danville, Pennsylvania.	78. West Branch of Susquehanna River at Allenwood, Pennsylvania.	79. Juniata River at Newport, Pennsylvania.	80. Susquehanna River at Harrisburg, Pennsylvania.	81. Octoraro Creek at Rowlandsville, Maryland.	83. Patapsco River at Woodstock, Maryland.	86. Antietam Creek at Sharpsburg, Maryland.	90. Shenandoah River at Millville, West Virginia.	91. Potomac River at Point of Rocks, Maryland.
0.0	.....	.....	.....	.....	.....	3,000	.....	.....	.....	.....	750
0.2	.....	.....	.....	.....	.....	3,650	.....	.....	.....	.....	1,000
0.4	.....	.....	.....	.....	.....	4,350	.....	.....	.....	.....	1,400
0.6	.....	.....	.....	.....	.....	5,050	.....	.....	.....	740	1,800
0.8	.....	.....	.....	.....	.....	5,900	.....	.....	.....	940	2,400
1.0	.....	.....	.....	.....	.....	7,000	.....	.....	.....	1,140	3,100
1.2	.....	.....	.....	.....	.....	8,200	.....	.....	38	1,370	3,900
1.4	.....	.....	.....	.....	.....	9,450	.....	.....	60	1,650	4,700
1.6	.....	.....	.....	750	.....	10,750	.....	.....	105	1,950	5,500
1.8	.....	.....	970	1,050	.....	12,300	.....	.....	171	2,260	6,400
2.0	.....	.....	1,350	1,350	.....	13,900	.....	.....	233	2,600	7,300
2.2	.....	1,000	1,750	1,700	.....	15,500	.....	.....	294	2,960	8,300
2.4	1,750	1,200	2,250	2,150	.....	17,300	.....	.....	356	3,340	9,300
2.6	2,100	1,400	2,750	2,650	.....	19,300	.....	.....	417	3,740	10,300
2.8	2,600	1,600	3,300	3,250	600	21,300	.....	.....	479	4,160	11,300
3.0	3,300	1,860	3,900	4,000	1,000	23,400	.....	50	544	4,600	12,350
3.2	4,100	2,120	4,550	5,200	1,400	25,625	110	83	644	5,060	13,450
3.4	5,050	2,400	5,250	7,500	1,820	27,925	155	122	766	5,540	14,550
3.6	6,100	2,700	6,000	10,750	2,270	30,300	225	173	887	6,050	15,650
3.8	7,250	3,000	6,800	14,000	2,750	32,800	305	235	1,000	6,600	16,800
4.0	8,550	3,300	7,600	17,250	3,250	35,400	385	310	1,114	7,190	18,000
4.2	10,000	3,600	8,500	20,500	3,750	38,100	465	400	1,227	7,790	19,200
4.4	11,650	3,940	9,400	23,750	4,300	41,100	545	520	1,340	8,410	20,400
4.6	13,350	4,340	10,400	27,000	4,900	44,590	635	670	1,454	9,040	21,600
4.8	15,050	4,760	11,400	30,250	5,500	48,170	725	835	1,567	9,680	22,800
5.0	16,750	5,200	12,500	33,500	6,200	51,750	815	1,000	1,680	10,320	24,000
5.2	18,500	5,700	13,700	36,750	6,900	55,330	910	1,200	1,794	10,960	25,200
5.4	20,300	6,250	14,900	40,000	7,700	58,910	1,010	1,400	1,908	11,600	26,400
5.6	22,150	6,850	16,100	43,250	8,500	62,490	1,110	1,600	2,022	12,240	27,600
5.8	24,050	7,560	17,390	46,500	9,350	66,070	1,210	1,800	2,136	12,880	28,800
6.0	25,950	8,340	18,800	49,750	10,250	69,650	1,314	2,000	2,250	13,520	30,100
6.2	27,850	9,240	20,240	53,000	11,150	73,230	1,418	2,205	2,364	14,160	31,400
6.4	29,750	10,260	21,680	56,250	12,060	76,810	1,522	2,410	2,478	14,800	32,700
6.6	31,700	11,360	23,120	59,500	13,000	80,390	1,628	2,615	2,592	15,440	34,100
6.8	33,710	12,480	24,560	62,750	14,000	83,970	1,736	2,820	2,706	16,080	35,500
7.0	35,750	13,600	26,000	66,000	15,000	87,550	1,844	3,025	2,820	16,720	36,950
7.5	40,900	16,400	29,600	74,125	17,500	96,500	2,114	3,538	3,105	.....	40,800
8.0	46,050	19,200	33,200	82,250	20,000	105,450	.....	4,050	3,390	.....	44,900
8.5	51,200	22,000	36,800	.....	22,500	114,400	.....	4,562	.....	.....	49,300
9.0	56,350	24,800	40,400	.....	25,000	123,350	.....	.....	.....	.....	53,850
9.5	61,500	27,600	44,000	.....	27,500	132,300	.....	.....	.....	.....	58,400
10.0	.....	30,400	47,600	.....	30,000	141,250	.....	.....	.....	.....	62,950
10.5	.....	32,200	51,200	.....	32,500	150,200	.....	.....	.....	.....	67,500
11.0	.....	36,000	54,800	.....	35,000	159,150	.....	.....	.....	.....	72,050
11.5	.....	38,800	58,400	.....	.....	168,100	.....	.....	.....	.....	76,600
12.0	.....	41,600	62,000	.....	.....	177,050	.....	.....	.....	.....	81,150
12.5	.....	44,400	.....	.....	.....	186,000	.....	.....	.....	.....	85,700
13.0	.....	47,200	.....	.....	.....	194,950	.....	.....	.....	.....	90,250
13.5	.....	50,000	.....	.....	.....	203,900	.....	.....	.....	.....	94,800
14.0	.....	52,800	.....	.....	.....	212,850	.....	.....	.....	.....	99,350
14.5	.....	.....	.....	.....	.....	221,800	.....	.....	.....	.....	103,900
15.0	.....	.....	.....	.....	.....	230,750	.....	.....	.....	.....	108,450
15.5	.....	.....	.....	.....	.....	239,700	.....	.....	.....	.....	113,000
16.0	.....	.....	.....	.....	.....	248,650	.....	.....	.....	.....	117,550
16.5	.....	.....	.....	.....	.....	257,600	.....	.....	.....	.....	122,100
17.0	.....	.....	.....	.....	.....	266,550	.....	.....	.....	.....	126,650

Rating tables for stations in Virginia and North Carolina.

[Number in box head refers to page in Water-Supply and Irrigation Paper No. 35 or No. 36.]

Gage height in feet.	Discharge in second-feet.											
	95. North (of James) River at Glasgow, Virginia.	97. James River at Buchanan, Virginia.	107. Roanoke River at Roanoke, Virginia.	109. Roanoke River at Scotland Neck, North Carolina.	110. Tar River at Tarboro, North Carolina.	111. Neuse River at Selma, North Carolina.	112. Haw River at Moncure, North Carolina.	113. Deep River at Moncure, North Carolina.	115. Cape Fear River at Fayetteville, North Carolina.	116. Yadkin River at Salisbury, North Carolina.	118. Yadkin River at Norwood, North Carolina.	120. Catawba River at Catawba, North Carolina.
0.2	.....	.....	.....	.....	.....	145	.....	.....	.....	.....	.....	.....
0.4	.....	.....	.....	.....	370	175	.....	.....	.....	.....	.....	.....
0.6	155	.....	70	.....	410	215	.....	210	.....	.....	.....	.....
0.8	180	.....	110	.....	453	255	.....	230	.....	.....	.....	.....
1.0	200	.....	170	2,270	500	285	290	250	489	.....	1,500	.....
1.2	220	.....	240	2,410	555	335	350	280	550	.....	2,080	.....
1.4	290	.....	325	2,550	615	377	415	330	612	.....	2,670	.....
1.6	410	.....	420	2,690	675	419	500	380	678	1,600	3,270	850
1.8	560	370	540	2,830	735	462	600	440	744	2,000	3,900	1,050
2.0	730	530	670	2,970	800	506	700	500	810	2,500	4,600	1,270
2.2	920	690	820	3,110	875	551	820	560	876	3,100	5,400	1,540
2.4	1,120	850	1,010	3,250	953	600	950	630	946	3,700	6,240	1,840
2.6	1,340	1,010	1,240	3,390	1,031	650	1,090	715	1,022	4,300	7,080	2,200
2.8	1,570	1,180	1,540	3,530	1,110	700	1,230	805	1,103	5,000	7,920	2,600
3.0	1,810	1,380	1,920	3,670	1,200	750	1,370	900	1,187	5,700	8,760	3,000
3.2	2,070	1,590	2,325	3,810	1,300	800	1,530	1,070	1,273	6,500	9,630	3,450
3.4	2,330	1,810	2,735	3,950	1,400	860	1,690	1,240	1,367	7,300	10,600	3,900
3.6	2,610	2,070	3,145	4,090	1,500	920	1,850	1,410	1,467	8,100	11,780	4,375
3.8	2,890	2,340	3,555	4,230	1,600	980	2,010	1,580	1,567	8,900	12,980	4,875
4.0	3,190	2,620	3,965	4,370	1,700	1,040	2,170	1,750	1,674	9,700	14,180	5,400
4.2	3,490	2,920	4,375	4,510	1,810	1,100	2,340	1,940	1,782	10,500	15,380	5,940
4.4	3,790	3,220	4,785	4,650	1,920	1,168	2,510	2,130	1,890	11,300	16,580	6,495
4.6	4,090	3,520	5,195	4,790	2,030	1,236	2,680	2,320	1,994	12,100	17,820	7,065
4.8	4,390	3,830	5,605	4,930	2,140	1,305	2,850	2,510	2,102	12,900	19,060	7,640
5.0	4,690	4,150	6,015	5,070	2,250	1,385	3,020	2,700	2,210	13,700	20,300	8,225
5.5	5,490	5,050	7,040	5,420	2,550	1,585	3,445	3,175	2,470	15,700	23,510	9,700
6.0	6,400	6,030	8,065	5,770	2,865	1,805	3,870	3,650	2,740	17,900	26,800	11,175
6.5	7,420	7,080	9,090	6,120	3,200	2,030	4,310	4,125	3,010	20,200	30,300	12,650
7.0	8,540	8,130	10,115	6,525	3,550	2,255	4,760	4,600	3,280	22,700	33,800	14,125
7.5	9,910	9,300	11,140	6,970	3,910	2,500	5,210	5,100	3,550	25,650	37,800	15,600
8.0	11,400	10,600	12,165	7,420	4,285	2,750	5,660	5,600	3,822	29,100	41,800	17,075
8.5	12,900	11,980	.....	7,870	4,685	3,000	6,110	6,100	4,102	33,000	46,300	18,550
9.0	14,430	13,310	.....	8,345	5,085	3,250	6,600	6,600	4,382	37,000	51,000	20,025
9.5	15,930	14,740	.....	8,840	5,500	3,500	7,100	7,100	4,672	41,000	56,250	21,500
10.0	17,430	16,240	.....	9,340	5,915	3,750	7,600	7,600	4,955	45,000	61,500	22,975
10.5	18,930	17,820	.....	9,840	6,330	4,000	8,100	8,100	5,245	49,000	66,750	24,450
11.0	20,430	19,430	.....	10,340	6,750	4,280	8,600	8,600	5,535	53,000	72,000	25,925
11.5	21,930	21,170	.....	10,840	7,175	4,610	9,100	9,100	5,833	57,000	.....	27,400
12.0	23,430	22,920	.....	11,340	7,600	4,960	9,600	9,600	6,133	61,000	.....	28,875
12.5	24,930	24,680	.....	11,840	8,025	5,320	10,100	10,100	6,443	65,000	.....	30,350
13.0	26,430	26,430	.....	12,340	8,470	5,695	10,600	10,600	6,733	69,000	.....	31,825
13.5	.....	28,700	.....	12,890	8,920	6,070	11,100	11,100	7,033	73,000	.....	33,300
14.0	.....	30,850	.....	13,440	9,370	6,450	11,600	11,600	7,333	77,000	.....	34,775
14.5	.....	33,000	.....	14,040	9,820	6,850	12,100	12,100	7,633	81,000	.....	36,250
15.0	.....	35,150	.....	14,640	10,270	7,250	12,600	12,600	7,933	85,000	.....	37,725
16.0	.....	39,450	.....	15,940	11,170	8,050	13,600	13,680	8,541	93,000	.....	40,675
17.0	.....	43,750	.....	17,240	12,070	8,850	14,600	14,780	9,161	101,000	.....	43,650
18.0	.....	48,050	.....	18,600	12,970	9,650	15,600	15,880	9,781	109,000	.....	46,650
19.0	.....	52,350	.....	20,100	13,870	10,450	16,600	16,980	10,401	117,000	.....	49,650
20.0	.....	.....	.....	22,400	14,850	11,250	17,600	18,080	11,569	.....	.....	52,650
25.0	.....	.....	.....	29,700	19,850	.....	22,600	23,580	18,364	.....	.....	.....
30.0	.....	.....	.....	.....	.....	.....	.....	.....	25,159	.....	.....	.....
35.0	.....	.....	.....	.....	.....	.....	.....	.....	33,000	.....	.....	.....
40.0	.....	.....	.....	.....	.....	.....	.....	.....	44,000	.....	.....	.....
45.0	.....	.....	.....	.....	.....	.....	.....	.....	54,500	.....	.....	.....
50.0	.....	.....	.....	.....	.....	.....	.....	.....	65,000	.....	.....	.....

Rating tables for stations in South Carolina and Georgia.

[Number in box head refers to page in Water-Supply and Irrigation Paper No. 36.]

Gage height in feet.	Discharge in second-feet.											
	121. Catawba River at Rockhill, South Carolina.	123. Broad River at Gaffney, South Carolina.	125. Broad River at Alston, South Carolina.	126. Saluda River at Waterloo, South Carolina.	127. Tugaloo River at Madison, South Carolina.	129. Savannah River at Calhoun Falls, South Carolina.	130. Savannah River at Augusta, Georgia.	131. Broad River at Carlton, Georgia.	133. Oconee River at Dublin, Georgia.	134. Yellow River at Almon, Georgia.	136. Ocmulgee River at Macon, Georgia.	139. Chattahoochee River at Oakdale, Georgia, lower gage.
									a			
−0.2	.....	.....	.....	.....	.....	.....	.....	.....	1,300	.....	.....	.....
0.0	.....	.....	.....	.....	.....	.....	.....	.....	1,425	.....	.....	400
0.2	.....	.....	.....	.....	.....	.....	.....	.....	1,552	.....	580	480
0.4	.....	.....	.....	.....	.....	.....	.....	.....	1,681	.....	620	580
0.6	.....	.....	.....	.....	.....	.....	.....	.....	1,812	.....	690	680
0.8	.....	.....	.....	.....	563	.....	.....	.....	1,945	.....	770	780
1.0	.....	.....	.....	.....	665	.....	.....	.....	2,080	120	850	900
1.2	.....	600	.....	.....	767	.....	.....	.....	2,218	147	940	1,020
1.4	1,560	780	.....	.....	869	.....	.....	.....	2,358	175	1,040	1,150
1.6	1,750	1,060	.....	.....	971	.....	.....	380	2,500	212	1,140	1,280
1.8	2,030	1,350	.....	.....	1,073	.....	.....	450	2,644	255	1,250	1,420
2.0	2,390	1,650	1,520	300	1,175	.....	.....	540	2,790	300	1,360	1,560
2.2	2,830	1,960	1,800	320	1,277	1,990	.....	660	2,938	345	1,480	1,700
2.4	3,380	2,300	2,160	350	1,379	2,190	.....	800	3,089	390	1,600	1,850
2.6	4,060	2,660	2,520	400	1,481	2,490	.....	940	3,243	435	1,720	2,000
2.8	4,880	3,020	2,900	465	1,583	2,870	.....	1,080	3,400	480	1,840	2,150
3.0	5,750	3,400	3,300	550	1,685	3,420	.....	1,220	3,560	525	1,960	2,300
3.2	6,632	3,820	3,700	650	1,787	4,160	.....	1,370	3,720	570	2,080	2,470
3.4	7,516	4,260	4,100	750	1,889	5,036	.....	1,520	3,890	615	2,200	2,650
3.6	8,400	4,720	4,500	850	1,991	5,924	.....	1,680	4,070	660	2,320	2,830
3.8	9,284	5,200	4,900	950	2,093	6,812	.....	1,840	4,260	705	2,440	3,050
4.0	10,168	5,680	5,300	1,050	2,195	7,700	2,350	2,000	4,460	750	2,560	3,250
4.2	11,052	6,160	5,800	1,156	2,310	8,588	2,470	2,180	4,672	795	2,680	3,450
4.4	11,936	6,640	6,300	1,262	2,435	9,476	2,695	2,360	4,888	840	2,800	3,650
4.6	12,820	7,120	6,800	1,368	2,570	10,364	2,725	2,550	5,108	885	2,920	3,900
4.8	13,704	7,600	7,360	1,474	2,710	11,252	2,860	2,750	5,332	930	3,040	4,150
5.0	14,588	8,080	7,920	1,580	2,860	12,140	3,000	2,950	5,560	975	3,160	4,400
5.2	15,472	8,560	8,500	1,686	3,020	13,028	3,160	3,160	5,788	1,020	3,280	4,660
5.4	16,356	9,040	9,100	1,805	3,180	13,916	3,340	3,390	6,016	1,065	3,400	4,920
5.6	17,240	9,520	9,700	1,935	3,340	14,804	3,540	3,640	6,244	1,110	3,520	5,180
5.8	18,124	10,000	10,300	2,065	3,500	15,692	3,760	3,900	6,472	1,155	3,640	5,440
6.0	19,008	10,480	11,000	2,200	3,660	16,580	4,000	4,160	6,700	.....	3,760	5,700
6.5	21,218	11,680	12,750	2,550	4,060	18,800	4,620	4,825	7,270	.....	4,060	6,370
7.0	23,428	12,880	14,700	2,900	4,460	21,020	5,300	5,500	7,840	.....	4,360	7,000
7.5	25,638	14,080	16,950	3,275	4,860	23,240	6,050	6,175	8,410	.....	4,660	7,650
8.0	27,848	15,280	19,200	3,670	5,260	25,460	6,800	6,850	8,980	.....	5,010	8,300
8.5	30,058	16,480	21,450	4,075	5,660	27,680	7,600	7,525	9,550	.....	5,410	8,950
9.0	32,268	17,680	23,700	4,500	6,060	29,900	8,400	8,200	10,120	.....	5,810	9,600
9.5	34,478	18,880	25,950	4,950	6,460	32,120	9,250	8,875	10,690	.....	6,250	10,250
10.0	36,688	20,080	28,200	5,400	6,860	34,340	10,100	9,550	11,260	.....	6,820	10,900
11.0	40,108	22,480	32,700	6,350	7,660	38,780	11,900	10,900	12,400	.....	8,120	12,200
12.0	45,528	24,880	37,200	7,350	8,460	43,220	13,800	12,250	13,540	.....	10,010	13,500
13.0	49,948	.....	41,700	8,400	9,260	47,660	15,800	13,600	14,680	.....	12,900	14,800
14.0	54,368	.....	46,200	9,500	10,060	52,100	17,900	14,950	15,820	.....	16,000	16,100
15.0	58,788	.....	50,700	10,650	10,860	.....	20,100	16,300	16,960	.....	19,200	17,400
16.0	62,208	.....	55,200	11,850	11,660	.....	22,400	17,650	18,100	.....	22,400	18,700
18.0	72,048	.....	64,200	14,350	.....	.....	27,300	.....	20,380	.....	.....	21,300
20.0	.....	.....	.....	.....	.....	.....	33,300	.....	22,660	.....	.....	23,900
22.0	.....	.....	.....	.....	.....	.....	41,000	.....	24,940	.....	.....	26,500
24.0	.....	.....	.....	.....	.....	.....	52,000	.....	27,220	.....	.....	29,100
26.0	.....	.....	.....	.....	.....	.....	68,800	.....	.....	.....	.....	31,700

a Continued: Gage height −1.20, discharge 890; gage height −1.00, discharge 950, gage height −0.8, discharge 1,015; gage height −0.6, discharge 1,095; gage height −0.4, discharge 1,185.

Rating tables for stations in Georgia, Alabama, Maryland, and West Virginia.

[Number in box head refers to page in Water-Supply and Irrigation Paper No. [illegible]]

Gage height in feet.	Discharge in second-feet.											
	139. Chattahoochee River at Oakdale, Georgia, upper gage.	142. Chattahoochee River at West Point, Georgia.	143. Etowah River at Canton, Georgia.	144. Coosawattee River at Carters, Georgia.	146. Oconee River at Rocky, Georgia.	148. Coosa River at Rome, Georgia.	149. Coosa River at Riverside, Alabama.	152. Tallapoosa River at Milstead, Alabama.	156. Black Warrior River at Tuscaloosa, Alabama.	159. Youghiogheny River at Friendsville, Maryland.	163. Greenbrier River at Alderson, West Virginia.	164. New River at Fayette, West Virginia.
—0.4	.....	.....	[illegible]	.....	.....	.....	.....	.....	[illegible]	.....	.....	.....
—0.2	.....	.....	[illegible]	.....	.....	.....	.....	.....	[illegible]	.....	.....	.....
0.0	.....	.....	[illegible]	.....	.....	.....	.....	.....	[illegible]	.....	.....	1.400
0.2	910	.....	665	.....	.....	.....	.....	.....	340	.....	.....	1.550
0.4	1.000	.....	[illegible]	.....	.....	1.550	.....	.....	400	.....	.....	1.700
0.6	1.100	.....	[illegible]	[illegible]	.....	[illegible]	.....	.....	460	.....	.....	1.850
0.8	1.220	.....	1.154	[illegible]	.....	[illegible]	.....	440	[illegible]	.....	.....	2.000
1.0	1.350	955	[illegible]	[illegible]	460	[illegible]	[illegible]	[illegible]	[illegible]	.....	.....	2.150
1.2	1.490	1.000	1.4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.....	[illegible]	[illegible]
1.4	1.630	1.180	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.154	[illegible]	.....	[illegible]	2.480
1.6	1.780	1.380	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.....	[illegible]	2.660
1.8	1.940	1.600	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.....	[illegible]	[illegible]
2.0	2.100	1.840	[illegible]	[illegible]	[illegible]	[illegible]	4.400	[illegible]	[illegible]	.....	[illegible]	3.050
2.2	2.270	2.100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.....	[illegible]	[illegible]
2.4	2.450	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.....	[illegible]	[illegible]
2.6	2.630	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.....	[illegible]	[illegible]
2.8	2.810	3.000	[illegible]	[illegible]	[illegible]	4.3[illegible]	[illegible]	[illegible]	[illegible]	.....	1.555	[illegible]
3.0	3.000	3.340	2.980	[illegible]	[illegible]	4.730	7.100	2.132	1.470	.....	1.900	4.200
3.2	3.200	3.700	3.146	1.440	1.175	5.100	7.700	3.375	1.570	.....	2.330	4.480
3.4	3.405	4.080	3.312	1.566	1.275	5.500	8.330	3.624	1.670	.....	2.770	4.760
3.6	3.615	4.480	3.47[illegible]	1.696	1.380	5.900	8.970	3.970	1.780	.....	3.240	5.060
3.8	3.825	4.920	3.644	1.834	1.490	6.300	9.630	4.116	1.890	.....	3.720	5.380
4.0	4.035	5.370	3.810	1.970	1.610	6.700	10.3[illegible]	4.362	2.000	260	4.200	5.700
4.2	4.250	5.880	3.976	2.106	1.730	7.102	11.040	4.608	2.111	295	4.680	6.080
4.4	4.470	6.400	4.142	2.242	1.860	7.504	11.740	4.854	2.222	330	5.160	6.442
4.6	4.700	6.940	4.308	2.37[illegible]	2.006	7.906	12.520	5.100	2.333	425	5.660	6.890
4.8	4.930	7.490	4.474	2.514	2.160	8.308	13.260	5.346	2.444	520	6.140	7.338
5.0	5.160	8.040	4.640	2.650	2.330	8.710	14.000	5.592	2.555	640	6.700	7.786
5.5	5.850	9.420	5.055	2.990	2.790	9.715	15.850	6.207	2.822	1.050	8.000	8.908
6.0	6.600	10.900	5.470	3.330	3.230	10.720	17.700	6.822	3.110	1.600	9.500	10.025
6.5	7.350	12.180	5.885	3.670	3.690	11.725	19.550	7.437	3.370	2.170	11.000	11.146
7.0	8.100	13.560	6.300	4.010	4.150	12.730	21.400	8.052	3.665	2.740	12.500	12.280
7.5	8.850	14.950	6.715	4.350	4.610	13.735	23.250	8.667	3.925	3.310	14.300	13.490
8.0	9.600	16.400	7.130	4.690	5.070	14.740	25.100	9.282	4.220	3.880	15.600	14.920
8.5	10.350	17.850	7.545	5.030	5.530	15.745	26.950	9.897	4.48[illegible]	4.450	17.300	16.170
9.0	11.100	19.300	7.960	5.370	5.990	16.750	28.800	10.512	4.775	5.020	19.000	17.600
9.5	11.850	20.750	8.375	5.710	6.450	17.755	30.650	11.127	5.065	5.590	20.700	19.1[illegible]
10.0	12.600	22.200	8.790	6.050	6.910	18.760	32.500	11.742	5.330	[illegible]	22.500	20.9[illegible]
11.0	14.100	25.100	9.620	6.730	7.830	20.770	36.200	12.972	5.865	[illegible]	26.300	24.48[illegible]
12.0	.....	28.400	[illegible]	[illegible]	[illegible]	22.780	39.900	14.202	6.440	[illegible]	[illegible]	[illegible]
13.0	.....	[illegible]	[illegible]	[illegible]	[illegible]	24.790	43.600	15.432	6.996	[illegible]	[illegible]	[illegible]
14.0	.....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47.300	[illegible]	7.550	[illegible]	[illegible]	[illegible]
15.0	.....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16.0	.....	.....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.....	.....	[illegible]
17.0	.....	.....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.....	.....	[illegible]
18.0	.....	.....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.....	.....	[illegible]
19.0	.....	.....	.....	[illegible]	[illegible]	[illegible]	.....	[illegible]	[illegible]	.....	.....	[illegible]
20.0	.....	.....	.....	.....	[illegible]	[illegible]	.....	[illegible]	[illegible]	.....	.....	[illegible]
25.0	.....	.....	.....	.....	[illegible]	[illegible]	.....	[illegible]	[illegible]	.....	.....	74.470
30.0	.....	.....	.....	.....	.....	[illegible]	.....	[illegible]	[illegible]	.....	.....	[illegible]
35.0	.....	.....	.....	.....	.....	.....	.....	[illegible]	[illegible]	.....	.....	[illegible]
40.0	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]	.....	.....	.....
45.0	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]	.....	.....	.....
50.0	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]	.....	.....	.....
55.0	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]	.....	.....	.....
60.0	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]	.....	.....	.....

Rating tables for stations in North Carolina, Georgia, Tennessee, Ohio, and Montana.

[Number in box head refers to page in Water-Supply and Irrigation Paper No. 26 or No. 27].

Gage height in feet.	Discharge in second-feet.											
	165. French Broad River at Asheville, North Carolina.	167. Tuckasegee River at Bryson, North Carolina.	168. Little Tennessee River at Judson, North Carolina.	169. Hiwassee River at Murphy, North Carolina.	171. Toccoa River at Blueridge, Georgia.	174. Tennessee River at Chattanooga, Tennessee.	175. Olentangy River at Columbus, Ohio.	176. Scioto River at Columbus, Ohio.	185. West Gallatin River at Salesville, Montana.	186. Middle Creek at Bozeman, Montana.	205. Madison River at Redcliff, Montana.	208. Missouri River at Townsend, Montana.
								a				b
−0.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	380	.....	.....
0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	410	.....	.....
0.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	440	.....	.....
0.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	470	.....	2,000
0.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	500	.....	2,400
0.8	.....	.....	.....	.....	.....	6,600	.....	.....	.....	530	.....	2,800
1.0	.....	300	.....	.....	.....	7,300	30	15	.....	560	850	3,250
1.2	.....	460	.....	.....	.....	8,040	90	50	.....	590	1,500	3,750
1.4	.....	620	.....	.....	.....	8,820	160	100	.....	620	2,150	4,250
1.6	.....	824	.....	.....	.....	9,620	250	150	.....	650	2,800	4,800
1.8	.....	1,072	.....	.....	.....	10,430	360	200	.....	680	3,450	5,400
2.0	820	1,320	225	.....	255	11,250	490	250	.....	710	4,100	6,000
2.2	990	1,652	300	.....	305	12,080	640	300	.....	740	4,750	6,600
2.4	1,180	1,984	445	.....	370	12,930	810	350	.....	770	5,400	7,250
2.6	1,400	2,320	610	.....	475	13,800	1,000	400	.....	800	6,050	7,950
2.8	1,620	2,720	805	.....	610	14,680	1,210	460	650	.....	6,700	8,650
3.0	1,860	3,150	1,060	.....	760	15,600	1,430	540	690	.....	7,350	9,400
3.2	2,120	3,620	1,360	.....	912	16,550	1,660	640	740	.....	8,000	10,200
3.4	2,380	4,160	1,670	.....	1,064	17,550	1,900	760	810	.....	8,650	11,000
3.6	2,660	4,800	1,990	.....	1,216	18,550	2,140	900	900	.....	9,300	11,900
3.8	2,950	5,520	2,320	.....	1,368	19,600	2,390	1,050	1,010	.....	9,950	12,900
4.0	3,290	6,320	2,650	.....	1,520	20,800	2,640	1,210	1,160	.....	.....	14,000
4.2	3,710	7,150	3,020	.....	1,672	22,040	2,900	1,390	1,350	.....	.....	15,200
4.4	4,210	8,000	3,390	.....	1,824	23,280	3,170	1,570	1,580	.....	.....	16,400
4.6	4,760	8,850	3,770	225	1,976	24,520	3,450	1,750	1,870	.....	.....	17,600
4.8	5,350	9,700	4,160	280	2,128	25,760	3,745	1,940	2,210	.....	.....	19,000
5.0	6,020	10,550	4,550	340	2,280	27,000	4,060	2,140	2,600	.....	.....	20,400
5.5	7,420	12,675	5,600	620	2,660	30,100	4,830	2,670	3,600	.....	.....	25,000
6.0	9,820	14,800	6,750	1,280	3,040	33,200	5,830	3,230	4,600	.....	.....	30,650
6.5	11,720	16,925	7,975	2,130	3,420	36,300	.....	3,870	5,600	.....	.....	36,900
7.0	13,620	19,050	9,300	2,980	3,800	39,400	.....	4,610	6,600	.....	.....	43,150
7.5	15,520	21,300	10,720	3,830	4,180	42,500	.....	5,475	7,600	.....	.....	49,400
8.0	17,420	23,550	12,275	4,680	4,560	45,600	.....	6,400	8,600	.....	.....	55,650
8.5	19,320	26,050	14,087	5,530	4,940	48,700	.....	7,325	9,600	.....	.....	.....
9.0	21,220	28,550	16,100	6,380	5,320	51,800	.....	8,250	.....	.....	.....	.....
9.5	23,120	31,050	18,275	7,230	.....	54,900	.....	9,175	.....	.....	.....	.....
10.0	25,020	33,550	20,600	8,080	.....	58,000	.....	10,100	.....	.....	.....	.....
11.0	28,820	38,550	25,600	9,780	.....	64,200	.....	11,950	.....	.....	.....	.....
12.0	.....	.....	30,600	11,480	.....	70,400	.....	13,800	.....	.....	.....	.....
13.0	.....	.....	35,600	13,180	.....	76,600	.....	.....	.....	.....	.....	.....
14.0	.....	.....	.....	14,880	.....	82,800	.....	.....	.....	.....	.....	.....
15.0	.....	.....	.....	16,580	.....	89,000	.....	.....	.....	.....	.....	.....
16.0	.....	.....	.....	18,280	.....	95,200	.....	.....	.....	.....	.....	.....
17.0	.....	.....	.....	19,980	.....	101,400	.....	.....	.....	.....	.....	.....
18.0	.....	.....	.....	21,680	.....	107,600	.....	.....	.....	.....	.....	.....
19.0	.....	.....	.....	.....	.....	113,800	.....	.....	.....	.....	.....	.....
20.0	.....	.....	.....	.....	.....	120,000	.....	.....	.....	.....	.....	.....
22.0	.....	.....	.....	.....	.....	132,400	.....	.....	.....	.....	.....	.....
24.0	.....	.....	.....	.....	.....	144,800	.....	.....	.....	.....	.....	.....
26.0	.....	.....	.....	.....	.....	157,200	.....	.....	.....	.....	.....	.....
28.0	.....	.....	.....	.....	.....	169,600	.....	.....	.....	.....	.....	.....
30.0	.....	.....	.....	.....	.....	182,000	.....	.....	.....	.....	.....	.....
32.0	.....	.....	.....	.....	.....	194,400	.....	.....	.....	.....	.....	.....
34.0	.....	.....	.....	.....	.....	206,800	.....	.....	.....	.....	.....	.....
36.0	.....	.....	.....	.....	.....	219,200	.....	.....	.....	.....	.....	.....
40.0	.....	.....	.....	.....	.....	244,000	.....	.....	.....	.....	.....	.....

a Gage heights in the table should be increased by 8 feet, in order to correspond with gage heights on the rod at Columbus.

b Gage heights in the table should be increased by 88 feet, in order to correspond with gage heights on the rod at Townsend.

Rating tables for stations in Montana, Wyoming, Nebraska, and Colorado.

[Number in box head refers to page in Water-Supply and Irrigation Paper No. 37.]

Gage height in feet.	Discharge in second-feet.											
	209. Milk River at Havre, Montana, Jan. 1 to Sept. 17.	209. Milk River at Havre, Montana, Sept. 18 to Dec. 31.	212. Clear Creek at Buffalo, Wyoming.	214. Laramie River at Woods Landing, Wyoming.	216. Laramie River at Uva, Wyoming.	217. North Platte River at Orin Junction, Wyoming.	218. North Platte River at Gering, Nebraska.a	219. North Platte River at Camp Clarke, Nebraska.	220. North Platte River at North Platte, Nebraska, Jan. 1 to Sept. 20.	220. North Platte River at North Platte, Nebraska, Oct. 4 to Dec. 31.	222. Goose Creek at Lake Cheesman, Colorado.	223. South Fork of South Platte River at Lake Cheesman, Colorado.
0.2	90	.....	9	.....	.....	.....	.....	.....	.....	.....	.....	.....
0.3	98	.....	17	40	.....	.....	.....	.....	.....	.....	.....	.....
0.4	110	.....	25	45	.....	.....	.....	.....	.....	.....	.....	.....
0.5	124	.....	33	50	5	.....	.....	.....	.....	.....	.....	.....
0.6	140	.....	46	60	10	0	.....	.....	.....	.....	.....	.....
0.7	160	.....	64	70	15	40	.....	.....	.....	.....	7	.....
0.8	183	.....	82	85	21	100	.....	.....	.....	.....	9	24
0.9	208	.....	104	100	30	170	507	.....	.....	.....	12	36
1.0	235	80	131	125	40	240	893	.....	.....	.....	24	49
1.1	265	84	169	155	50	310	1,316	.....	.....	.....	38	65
1.2	295	90	209	200	62	380	1,777	.....	.....	.....	53	86
1.3	330	98	246	245	80	450	2,275	.....	.....	.....	68	115
1.4	365	110	286	290	100	525	2,811	.....	.....	.....	83	145
1.5	400	124	323	350	120	600	3,385	.....	889	.....	98	175
1.6	440	140	365	410	140	680	3,997	.....	1,149	622	.....	205
1.7	480	160	406	475	160	760	4,647	.....	1,495	713	.....	234
1.8	525	183	447	550	185	850	5,335	.....	1,845	984	.....	264
1.9	570	208	504	630	210	940	6,061	.....	2,215	1,270	.....	294
2.0	620	235	568	720	240	1,030	6,824	600	2,619	1,557	.....	323
2.2	725	295	657	960	300	1,230	8,465	1,049	3,427	2,275	.....	383
2.4	845	365	752	1,240	370	1,480	10,257	1,646	4,235	3,138	.....	442
2.6	980	.....	856	1,530	450	1,760	12,200	2,391	5,197	4,001	.....	501
2.8	1,135	.....	.....	1,820	540	2,070	14,295	3,285	6,317	.....	.....	561
3.0	1,305	.....	.....	2,110	660	2,400	16,541	4,327	7,437	.....	.....	621
3.2	1,480	.....	.....	2,400	810	2,780	18,939	5,517	8,557	.....	.....	680
3.4	1,680	.....	.....	2,690	1,000	3,240	21,489	6,855	9,851	.....	.....	740
3.6	1,880	.....	.....	2,980	1,200	3,790	24,189	8,342	11,330	.....	.....	800
3.8	2,080	.....	.....	3,270	1,405	4,555	.....	9,977	12,962	.....	.....	860
4.0	2,280	.....	.....	3,560	1,611	5,445	.....	11,760	14,606	.....	.....	.....
4.2	2,480	.....	.....	3,850	1,817	6,335	.....	13,691	16,257	.....	.....	.....
4.4	2,680	.....	.....	4,140	2,023	7,225	.....	15,771	17,894	.....	.....	.....
4.6	2,880	.....	.....	4,430	2,229	8,115	.....	18,000	.....	.....	.....	.....
4.8	.....	.....	.....	.....	2,435	9,005	.....	20,375	.....	.....	.....	.....
5.0	.....	.....	.....	.....	2,641	9,895	.....	22,900	.....	.....	.....	.....
5.2	.....	.....	.....	.....	2,847	10,785	.....	25,573	.....	.....	.....	.....
5.4	.....	.....	.....	.....	3,053	11,760	.....	28,394	.....	.....	.....	.....
5.6	.....	.....	.....	.....	3,259	12,835	.....	.....	.....	.....	.....	.....
5.8	.....	.....	.....	.....	3,465	14,020	.....	.....	.....	.....	.....	.....
6.0	.....	.....	.....	.....	3,611	15,230	.....	.....	.....	.....	.....	.....
6.2	.....	.....	.....	.....	.....	16,480	.....	.....	.....	.....	.....	.....
6.4	.....	.....	.....	.....	.....	17,770	.....	.....	.....	.....	.....	.....
6.6	.....	.....	.....	.....	.....	19,100	.....	.....	.....	.....	.....	.....
6.8	.....	.....	.....	.....	.....	20,470	.....	.....	.....	.....	.....	.....
7.0	.....	.....	.....	.....	.....	21,880	.....	.....	.....	.....	.....	.....
7.2	.....	.....	.....	.....	.....	23,330	.....	.....	.....	.....	.....	.....

a These rating tables were applied by the indirect method described on pages 323 et seq. of the Nineteenth Annual Report, Part IV.

Rating tables for stations in Colorado and Nebraska.

[Number in box head refers to page in Water-Supply and Irrigation Paper No. 37.]

Gage height in feet.	Discharge in second-feet.											
	224. South Platte River at Platte Canyon, Colorado.	225. South Platte River at Denver, Colorado.	226. South Platte River at Orchard, Colorado, Jan. 1 to Mar. 18.	226. South Platte River at Orchard, Colorado, Mar. 19 to Dec. 31.	227. Bear Creek at Morrison, Colorado.	228. Clear Creek at Forkscreek, Colorado.	229. South Boulder Creek at Marshall, Colorado.	231. Boulder Creek at Boulder, Colorado.	232. St. Vrain Creek at Lyons, Colorado.	233. Big Thompson Creek at Arkins, Colorado.	237. North Loup River at St. Paul, Nebraska. *b*	238. Middle Loup River at St. Paul, Nebraska. *b*
	a											
0.0	125	.....	.....	.....	.....	.....	.....	0	.....	.....	.....	.....
0.1	146	.....	.....	.....	0	.....	.....	7	.....	.....	.....	.....
0.2	168	.....	.....	.....	1	.....	.....	14	.....	4	.....	.....
0.3	190	.....	.....	.....	2	.....	.....	21	.....	8	.....	.....
0.4	213	.....	.....	.....	2	.....	.....	28	.....	19	.....	.....
0.5	236	.....	.....	.....	3	.....	.....	36	.....	35	.....	.....
0.6	260	.....	.....	.....	4	.....	.....	45	.....	60	.....	.....
0.7	284	.....	.....	.....	5	.....	7	55	.....	88	.....	.....
0.8	308	.....	.....	.....	7	.....	13	67	.....	116	.....	.....
0.9	333	.....	.....	.....	8	.....	20	80	.....	146	.....	.....
1.0	359	.....	.....	.....	9	.....	29	95	.....	176	.....	625
1.1	386	.....	.....	.....	10	.....	39	113	.....	206	.....	655
1.2	413	.....	.....	.....	11	.....	49	133	.....	236	.....	685
1.3	441	.....	.....	.....	12	.....	60	156	.....	267	.....	715
1.4	470	.....	.....	.....	13	32	72	182	.....	299	.....	745
1.5	500	.....	.....	.....	15	44	86	211	.....	331	465	780
1.6	531	.....	.....	.....	16	58	102	242	.....	365	530	820
1.7	563	.....	.....	.....	17	75	121	276	.....	399	600	865
1.8	596	.....	.....	.....	19	93	143	321	.....	433	680	925
1.9	631	.....	.....	19	21	112	167	366	13	469	750	990
2.0	669	.....	0	40	22	133	193	412	25	510	835	1,065
2.2	754	.....	40	115	25	179	248	504	51	619	1,000	1,250
2.4	850	.....	113	206	27	235	308	596	80	769	1,175	1,480
2.6	954	.....	195	340	31	299	375	688	113	1,003	1,360	1,740
2.8	1,066	.....	288	614	34	367	452	780	155	1,251	1,560	2,050
3.0	1,185	.....	408	936	37	441	536	.....	204	1,499	1,760	2,390
3.2	1,305	.....	593	1,258	41	522	.....	.....	263	1,747	1,960	.....
3.4	1,425	.....	968	1,580	46	614	.....	.....	353	.....	2,175	.....
3.6	1,545	.....	1,342	1,902	54	719	.....	.....	477	.....	2,400	.....
3.8	1,665	.....	1,716	2,224	64	832	.....	.....	601	.....	2,625	.....
4.0	1,785	.....	2,090	2,546	80	946	.....	.....	729	.....	2,900	.....
4.2	1,905	.....	2,464	2,868	99	1,060	.....	.....	857	.....	.....	.....
4.4	2,025	.....	2,838	3,190	119	1,174	.....	.....	985	.....	.....	.....
4.6	2,145	.....	3,214	3,512	141	1,288	.....	.....	1,113	.....	.....	.....
4.8	.....	52	3,590	3,834	166	1,402	.....	.....	.....	.....	.....	.....
5.0	.....	81	3,966	4,156	195	.....	.....	.....	.....	.....	.....	.....
5.2	.....	121	.....	.....	225	.....	.....	.....	.....	.....	.....	.....
5.4	.....	172	.....	.....	257	.....	.....	.....	.....	.....	.....	.....
5.6	.....	232	.....	.....	290	.....	.....	.....	.....	.....	.....	.....
5.8	.....	309	.....	.....	325	.....	.....	.....	.....	.....	.....	.....
6.0	.....	422	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6.2	.....	588	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6.4	.....	755	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6.6	.....	922	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6.8	.....	1,088	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7.0	.....	1,255	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7.2	.....	1,422	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

a Continued: Gage height −0.1, discharge 104; gage height −0.2, discharge 87; gage height −0.3, discharge 75; gage height −0.4, discharge 64; gage height −0.5, discharge 55; gage height −0.6, discharge 48; gage height −0.7, discharge 41; gage height −0.8, discharge 35; gage height −0.9, discharge 30; gage height −1.0, discharge 26; gage height −1.1, discharge 22; gage height −1.2, discharge 18.

b These rating tables were applied by the indirect method described on pages 323 et seq. of the Nineteenth Annual Report, Part IV.

Rating tables for stations in Nebraska, Kansas, and Colorado.

[Number in box head refers to page in Water-Supply and Irrigation Paper No. 87.]

Gage height in feet.	Discharge in second-feet.											
	240. Loup River at Columbus, Nebraska.a	242. Platte River at Columbus, Nebraska.a	243. Elkhorn River at Norfolk, Nebraska.a	244. Elkhorn River at Arlington, Nebraska.a	245. Republican River at Superior, Nebraska.	248. Republican River at Junction, Kansas.	249. Solomon River at Niles, Kansas.	250. Saline River at Salina, Kansas.	251. Smoky Hill River at Ellsworth, Kansas.	252. Blue River at Manhattan, Kansas.	253. Kansas River at Lecompton, Kansas, July 9 to Dec. 31.b	256. Lake Creek at Twin Lakes, Colorado.
0.2					90							
0.3					140							
0.4					190							
0.5			115	303	270							
0.6			140	340	350							
0.7			166	377	445							
0.8			194	415	560							
0.9			224	452	700							
1.0			256	490	860				20			
1.2			323	564	1,200				[illegible]			
1.4			396	639	1,580				[illegible]			
1.6			477	714					94			
1.8			562	789					[illegible]			
2.0			660	863					140		1,850	
2.2			820	938					230		2,070	
2.4			1,010	1,013					320		2,330	
2.6		1,676		1,098		115			335		2,580	411
2.8		2,324		1,162		205			390		2,860	496
3.0		3,100		1,240		295		40	450	150	3,150	568
3.2		4,000		1,330		395		60	520	200	3,460	696
3.4		5,000		1,462		500		70	610	270	3,780	834
3.6		6,050		1,610		615		80	710	340	4,130	1,006
3.8		7,400		1,781		735		95	830	420	4,480	1,206
4.0	898	9,200		1,977		870	30	110	980	500	4,850	
4.2	1,241	11,300		2,197		1,020	45	125	1,100	590	5,240	
4.4	1,620	13,450		2,441		1,180	62	140	1,250	680	5,640	
4.6	2,040	16,400				1,360	81	156	1,400	770	6,080	
4.8	2,500	19,700				1,570	100	173	1,550	860	6,500	
5.0	2,995	23,700				1,780	120	190	1,700	960	6,950	
5.2	3,530	28,400				2,030	142	206	1,850	1,060	7,420	
5.4	4,101					2,320	165	220	2,000	1,160	7,930	
5.6	4,712					2,610	190	236	2,150	1,270	8,470	
5.8	5,356					2,910	215	254	2,300	1,380	9,030	
6.0	6,040					3,230	242	270	2,460	1,500	9,600	
6.5	7,910					4,090	319	315	2,865	1,825	11,200	
7.0							400	360	3,290	2,175	13,000	
7.5							490	405	3,715	2,560	14,900	
8.0							600	457	4,160	2,970	16,800	
8.5							713	514	4,650	3,400		
9.0							834	565	5,150	3,850		
9.5							959	627	5,660	4,315		
10.0							1,087	690	6,230	4,800		
10.5							1,217	757	6,835	5,325		
11.0							1,351	830	7,460	5,870		
11.5							1,487	902	8,170	6,425		
12.0							1,625	977	8,950	7,000		
12.5							1,770	997	9,810	7,600		
13.0							1,920	1,060	10,986	8,240		
13.5							2,070			8,970		
14.0							2,220			9,800		
14.5							2,380			10,950		
15.0							2,540			12,000		
16.0							2,870			14,290		
17.0							3,220			16,530		
18.0							3,590			18,790		
20.0							4,450			23,240		

Discharges represent flow passing over dam only. Discharge of millrace should be added to give total flow of stream.

a These rating tables were applied by the indirect method described on pages 325 et seq. of the Nineteenth Annual Report, Part IV.

b Rating table from April 16 to July 8, 1896, as follows: Gage height 3.00, discharge 2,150; gage height 3.50, discharge 2,900; gage height 4.00, discharge 3,600; gage height 5.00, discharge 5,800; gage height 6.00, discharge 9,200; gage height 7.00, discharge 13,000; gage height 10.00, discharge 24,800.

Rating tables for stations in Colorado and Kansas.

[Number in box head refers to page in Water-Supply and Irrigation Paper No. 37.]

Gage height in feet.	Discharge in second-feet.											
	258. Arkansas River at Salida, Colorado.	258. Arkansas River at Canyon, Colorado.	259. Arkansas River at Pueblo, Colorado, Jan. 1 to June 21.	259. Arkansas River at Pueblo, Colorado, June 22 to Dec. 31.	260. Arkansas River at Nepesta, Colorado.	261. Arkansas River at Rockyford, Colorado.	263. Purgatory River at Trinidad, Colorado.	265. Arkansas River at Hutchinson, Kansas.	265. Verdigris River at Liberty, Kansas.	267. Neosho River at Iola, Kansas.	277. Rio Grande at Del Norte, Colorado.	279. Rio Grande at Cerrero, Colorado.
−0.6	.....	.....	.....	150	.....	.....	.....	.....	.....	.....	.....	.....
−0.5	.....	.....	.....	180	.....	.....	.....	.....	.....	.....	.....	.....
−0.4	.....	.....	.....	213	.....	.....	.....	.....	.....	.....	.....	.....
−0.3	.....	.....	.....	250	.....	.....	.....	.....	.....	.....	.....	.....
−0.2	.....	.....	.....	295	.....	.....	.....	.....	.....	.....	.....	.....
−0.1	.....	.....	.....	348	.....	.....	.....	.....	.....	.....	.....	.....
0.0	.....	.....	136	409	.....	.....	.....	.....	.....	.....	.....	.....
0.1	.....	.....	178	478	.....	.....	.....	.....	.....	.....	.....	.....
0.2	.....	.....	232	555	.....	.....	.....	.....	.....	.....	.....	.....
0.3	.....	.....	300	640	.....	.....	.....	.....	.....	.....	.....	.....
0.4	240	.....	372	733	.....	.....	.....	.....	.....	.....	.....	.....
0.5	256	.....	448	834	.....	.....	.....	.....	.....	.....	.....	.....
0.6	274	.....	527	941	.....	75	.....	.....	.....	.....	.....	.....
0.7	294	.....	609	1,050	.....	95	.....	.....	.....	.....	.....	9
0.8	317	.....	695	1,162	.....	115	.....	.....	.....	.....	.....	12
0.9	342	.....	784	1,276	.....	140	.....	.....	.....	.....	.....	20
1.0	368	.....	876	1,391	.....	190	.....	.....	.....	.....	.....	31
1.1	396	.....	972	1,507	.....	270	.....	25	.....	.....	.....	46
1.2	426	.....	1,070	1,624	.....	370	.....	30	.....	.....	.....	65
1.3	458	.....	1,172	1,743	.....	470	.....	40	.....	.....	218	93
1.4	494	.....	1,278	1,864	.....	570	.....	52	.....	.....	280	129
1.5	537	.....	1,392	1,988	.....	670	.....	70	0	.....	342	170
1.6	594	.....	1,510	2,114	.....	770	.....	90	2	.....	405	212
1.7	670	.....	1,633	2,240	.....	870	.....	115	5	0	470	254
1.8	764	.....	1,760	2,366	.....	970	.....	145	9	1	537	297
1.9	859	.....	1,892	2,492	.....	1,070	.....	180	14	25	606	339
2.0	954	135	2,028	2,618	.....	1,170	.....	220	20	50	678	381
2.2	1,144	186	2,314	2,870	.....	1,370	.....	385	39	110	829	.....
2.4	1,334	242	2,617	3,122	.....	1,570	.....	570	68	180	988	.....
2.6	1,524	316	2,936	3,374	.....	1,770	.....	800	110	260	1,161	.....
2.8	1,714	408	3,2[illegible]	3,626	154	1,970	.....	1,040	171	350	1,350	.....
3.0	1,904	560	3,588	3,878	191	2,170	.....	1,300	256	450	1,565	.....
3.2	2,094	807	3,914	4,130	235	2,370	.....	1,585	351	565	1,809	.....
3.4	2,284	1,057	4,240	4,383	285	2,570	16	1,895	450	700	2,061	.....
3.6	2,474	1,307	4,565	4,637	346	2,770	52	2,210	553	865	2,315	.....
3.8	2,664	1,557	4,891	4,891	427	2,970	109	2,570	660	1,050	.....	.....
4.0	2,854	1,807	.....	.....	610	3,170	230	3,010	770	1,250	.....	.....
4.2	3,044	2,057	.....	.....	974	3,370	492	3,600	890	1,465	.....	.....
4.4	3,234	2,307	.....	.....	1,337	3,570	1,012	4,210	1,010	1,700	.....	.....
4.6	3,424	2,557	.....	.....	1,701	.....	1,552	4,950	1,136	1,960	.....	.....
4.8	3,614	2,807	.....	.....	2,064	.....	2,092	5,810	1,268	2,250	.....	.....
5.0	3,804	3,057	.....	.....	2,428	.....	2,632	.....	1,400	2,550	.....	.....
5.5	.....	3,682	.....	.....	3,337	.....	.....	.....	1,760	3,310	.....	.....
6.0	.....	4,307	.....	.....	4,246	.....	.....	.....	2,160	4,100	.....	.....
6.5	.....	.....	.....	.....	5,156	.....	.....	.....	2,570	4,900	.....	.....
7.0	.....	.....	.....	.....	6,064	.....	.....	.....	2,980	5,700	.....	.....
7.5	.....	.....	.....	.....	6,521	.....	.....	.....	3,390	6,500	.....	.....
8.0	.....	.....	.....	.....	.....	.....	.....	.....	3,800	7,325	.....	.....
8.5	.....	.....	.....	.....	.....	.....	.....	.....	4,210	8,137	.....	.....
9.0	.....	.....	.....	.....	.....	.....	.....	.....	4,620	8,950	.....	.....
9.5	.....	.....	.....	.....	.....	.....	.....	.....	5,030	9,762	.....	.....
10.0	.....	.....	.....	.....	.....	.....	.....	.....	5,440	10,575	.....	.....
12.0	.....	.....	.....	.....	.....	.....	.....	.....	7,080	13,850	.....	.....
14.0	.....	.....	.....	.....	.....	.....	.....	.....	8,720	17,150	.....	.....
16.0	.....	.....	.....	.....	.....	.....	.....	.....	10,360	20,450	.....	.....
18.0	.....	.....	.....	.....	.....	.....	.....	.....	12,150	23,750	.....	.....

Rating tables for stations in New Mexico, Wyoming, Utah, and Colorado.

[Number in box head refers to page in Water-Supply and Irrigation Paper No. 37 or No. 38.]

Gage height in feet.	Discharge in second-feet.											
	280. Rio Grande at Embudo, New Mexico.	281. Rio Grande at Rio Grande, New Mexico.	286. Green River at Greenriver, Wyoming.	287. Black Fork of Green River at Granger, Wyoming.	292. Green River at Blake, Utah.	294. Grand River at Grand Junction, Colorado, right channel.	294. Grand River at Grand Junction, Colorado, left channel.	296. Uncompahgre River at Fort Crawford, Colorado.	297. Gunnison River at Grand Junction, Colorado.	298. Dolores River at Dolores, Colorado.	306. San Miguel River at Fallcreek, Colorado.	307. San Juan River at Arboles, Colorado.
−0.1				70								
0.0				80			0					
0.1				90			15					
0.2				100			33					
0.3				120			50					
0.4				150			70					
0.5			830	180			92					
0.6			910	210			113					
0.7			990	245			137					
0.8			1,070	280			162					
0.9			1,150	315			195					
1.0			1,240	350	1,000		228					
1.2			1,430	420	1,080		315					
1.4			1,640	510	1,160		433		788			
1.6			1,870	610	1,250		583		848			
1.8			2,120	720	1,400		765		908			
2.0			2,390	840	1,600		978		968			
2.2			2,700	970	2,020		1,221		1,061		25	
2.4			3,080	1,130	2,440		1,492		1,356	20	64	
2.6			3,540	1,320	2,860		1,791		1,652	37	105	
2.8			4,080	1,530	3,280		2,118	5	1,948	82	150	
3.0			4,710	1,780	3,700		2,473	10	2,246	164	204	
3.2			5,480	2,060	4,120		2,857	19	2,546	280	265	
3.4			6,340	2,340	4,540	650	3,267	33	2,847	412	340	
3.6		100	7,263	2,620	4,960	1,740	3,701	59	3,162	555	449	
3.8		120	8,189	2,900	5,380	1,860	4,156	102	3,512	700	682	
4.0		150	9,115	3,180	5,800	1,990	4,631	150	3,902	847	934	
4.2		190	10,041	3,460	6,220	2,180	5,126	206	4,332	1,001		
4.4		230	10,967	3,740	6,650	2,450	5,641	278	4,802	1,160		
4.6		280	11,893	4,020	7,350	2,770	6,176	389	5,312	1,327		
4.8		340	12,819	4,300	8,100	3,120	6,731	512	5,862	1,506		
5.0		420	13,745	4,580	9,000	3,480	7,306	636	6,452			
5.2		510	14,671	4,860	10,200	3,860	7,898	760	7,082			
5.4		610	15,597	5,140	11,800	4,260	8,501	884	7,736			
5.6		740	16,523	5,420	13,700	4,680	9,109	1,008	8,430			96
5.8		890	17,449	5,700	15,600	5,120	9,719	1,132	9,164			138
6.0		1,090	18,375	5,960	17,500	5,590	10,329		9,938			200
6.2		1,330	19,301	6,240	19,400	6,080	10,939		10,752			328
6.4		1,590	20,227	6,520	21,300	6,590	11,549		11,606			516
6.6	65	1,910	21,153		23,200	7,130			12,500			737
6.8	115	2,250			25,100	7,690			13,434			1,011
7.0	185	2,670			27,000	8,270			14,380			1,286
7.5	375	3,770			31,750	9,860			16,750			1,976
8.0	610	4,910			36,500	11,610						
8.5	890	6,100			41,250	13,530						
9.0	1,250	7,300			46,000	15,610						
9.5	1,625	8,500			50,750	17,900						
10.0		9,700			55,500	20,390						
10.5					60,250	23,030						
11.0					65,000	25,800						
11.5						28,600						

Rating tables for stations in Colorado, Arizona, Nevada, and Idaho.

[Number in box head refers to page in Water-Supply and Irrigation Paper No. 38.]

Gage height in feet.	Discharge in second-feet.											
	308. Piedra River at Arboles, Colorado.	309. Los Pinos River at Ignacio, Colorado.	310. Animas River at Durango, Colorado.	311. Florida River at Durango, Colorado.	312. Mancos River at Mancos, Colorado.	313. Gila River at San Carlos, Arizona.	325. North Fork of Humboldt River at Peko, Nevada.	326. Humboldt River at Elko, Nevada.	328. South Fork of Humboldt River at Mason's ranch, Nevada.	329. Humboldt River at Golconda, Nevada.	330. Humboldt River at Oreana, Nevada.	332. Bear River at Battlecreek, Idaho, Aug. 4 to Dec. 31. a
0.4	.....	.....	.....	.....	.....	.....	.....	.....	7	.....	.....	.....
0.5	.....	.....	.....	.....	.....	.....	.....	.....	15	15	.....	.....
0.6	.....	.....	.....	4	.....	.....	.....	.....	24	17	.....	.....
0.7	.....	.....	.....	9	0	.....	.....	.....	35	20	.....	.....
0.8	.....	.....	.....	16	1	.....	.....	.....	47	24	47	.....
0.9	.....	.....	.....	24	3	.....	.....	.....	60	29	59	.....
1.0	.....	.....	.....	32	5	.....	.....	.....	74	35	72	.....
1.1	.....	.....	.....	40	8	.....	.....	.....	89	41	87	.....
1.2	.....	.....	.....	50	12	.....	.....	.....	105	47	104	.....
1.3	.....	.....	.....	62	19	.....	.....	.....	122	54	123	.....
1.4	.....	.....	.....	75	29	.....	0.2	.....	141	62	144	.....
1.5	.....	.....	.....	89	42	60	1.0	.....	161	70	167	.....
1.6	.....	.....	.....	105	60	80	2.5	.....	182	78	191	930
1.7	.....	.....	.....	121	81	110	5	1	204	87	217	980
1.8	.....	.....	.....	139	102	140	8	7	227	96	245	1,030
1.9	.....	.....	.....	158	123	170	11	14	251	105	275	1,085
2.0	.....	.....	.....	179	144	200	14	22	276	114	308	1,140
2.1	.....	.....	.....	200	165	230	18	32	301	124	343	1,200
2.2	.....	36	.....	223	186	260	23	43	327	134	381	1,260
2.3	.....	49	.....	.....	207	290	29	56	354	145	422	1,325
2.4	25	67	.....	.....	228	330	35	70	382	156	466	1,390
2.5	38	89	.....	.....	249	370	42	86	410	168	512	1,460
2.6	52	124	.....	.....	270	410	50	104	439	180	561	1,530
2.7	68	180	.....	.....	291	460	59	123	469	193	613	1,605
2.8	88	236	.....	.....	312	520	69	144	499	206	668	1,680
2.9	111	292	.....	.....	333	590	80	166	529	220	725	1,760
3.0	138	349	.....	.....	354	680	92	190	559	235	785	1,845
3.2	200	463	.....	.....	.....	960	122	240	619	266	914	2,030
3.4	277	577	.....	.....	.....	1,498	160	292	679	298	1,055	.....
3.6	365	691	.....	.....	.....	2,174	207	346	740	332	1,205	.....
3.8	467	805	.....	.....	.....	2,850	263	402	801	367	1,362	.....
4.0	583	919	.....	.....	.....	3,526	327	461	862	404	1,523	.....
4.2	704	1,033	.....	.....	.....	4,202	396	525	922	443	1,688	.....
4.4	835	1,147	.....	.....	.....	4,878	469	594	983	485	1,858	.....
4.6	974	1,261	.....	.....	.....	5,554	546	667	1,045	530	2,033	.....
4.8	1,112	1,375	.....	.....	.....	6,230	628	743	1,106	578	2,212	.....
5.0	1,251	.....	.....	.....	.....	6,906	715	822	1,168	629	2,395	.....
5.2	1,390	.....	.....	.....	.....	7,582	806	903	1,230	684	.....	.....
5.4	1,529	.....	.....	.....	.....	8,258	899	987	1,292	742	.....	.....
5.6	.....	.....	.....	.....	.....	8,934	996	1,073	1,354	803	.....	.....
5.8	.....	.....	.....	.....	.....	9,610	1,094	1,166	1,416	868	.....	.....
6.0	.....	.....	.....	.....	.....	10,286	1,192	1,257	1,478	937	.....	.....
6.2	.....	.....	.....	.....	.....	.....	1,290	1,352	.....	1,011	.....	.....
6.4	.....	.....	168	.....	.....	.....	1,388	1,449	.....	1,093	.....	.....
6.6	.....	.....	237	.....	.....	.....	1,486	1,550	.....	1,183	.....	.....
6.8	.....	.....	315	.....	.....	.....	1,584	1,655	.....	1,281	.....	.....
7.0	.....	.....	402	.....	.....	.....	1,682	1,763	.....	1,387	.....	.....
7.2	.....	.....	504	.....	.....	.....	.....	1,873	.....	1,501	.....	.....
7.4	.....	.....	624	.....	.....	.....	.....	1,986	.....	1,623	.....	.....
7.6	.....	.....	786	.....	.....	.....	.....	2,101	.....	1,753	.....	.....
7.8	.....	.....	970	.....	.....	.....	.....	2,218	.....	1,888	.....	.....
8.0	.....	.....	1,160	.....	.....	.....	.....	2,339	.....	2,026	.....	.....
8.4	.....	.....	1,550	.....	.....	.....	.....	.....	.....	2,302	.....	.....
8.8	.....	.....	1,947	.....	.....	.....	.....	.....	.....	.....	.....	.....
9.2	.....	.....	2,364	.....	.....	.....	.....	.....	.....	.....	.....	.....
9.6	.....	.....	2,800	.....	.....	.....	.....	.....	.....	.....	.....	.....

a Rating table applicable from Jan. 1 to June 29 is the same as for 1898.

Rating tables for stations in Utah and Idaho.

[Number in box head refers to page in Water-Supply and Irrigation Paper No. 38.]

Gage height in feet.	Discharge in second-feet.											
	334. Logan River at Logan, Utah.	335. Bear River at Collinston, Utah.	337. Weber River at Uinta, Utah.	338. Provo River at Provo, Utah, Jan. 1 to June 22.	338. Provo River at Provo, Utah, June 23 to Oct. 21.	350. Portneuf River at Pocatello, Idaho.	351. Snake River at Montgomery, Idaho.	353. Little Wood River at Toponis, Idaho.	354. Malade River at Toponis, Idaho.	355. Malade River at Bliss, Idaho.	356. Bruneau River at Grandview, Idaho.	356. Boise River at Boise, Idaho.
0.9	.....	.....	.....	.....	.....	.....	.....	0.1	.....	.....	.....	.....
1.0	.....	.....	.....	.....	.....	.....	.....	0.5	.....	.....	10	867
1.1	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	25	986
1.2	.....	790	.....	.....	.....	.....	.....	1	5	.....	45	1,105
1.3	.....	870	.....	.....	.....	.....	.....	2	6	.....	55	1,224
1.4	.....	950	.....	.....	.....	.....	.....	2	6	.....	65	1,343
1.5	.....	1,050	320	.....	.....	.....	.....	2	7	.....	80	1,462
1.6	.....	1,150	375	.....	.....	.....	.....	4	7	.....	100	1,581
1.7	.....	1,260	445	.....	.....	.....	.....	6	8	.....	120	1,700
1.8	.....	1,370	520	.....	.....	.....	.....	8	9	.....	140	1,819
1.9	.....	1,485	595	.....	.....	.....	.....	10	10	.....	170	1,938
2.0	.....	1,600	675	.....	.....	.....	4,400	12	12	.....	200	2,057
2.1	.....	1,720	766	.....	.....	.....	4,500	14	14	1,060	230	2,197
2.2	.....	1,840	857	.....	.....	.....	4,600	18	18	1,120	270	2,390
2.3	200	1,965	948	.....	.....	.....	4,700	22	30	1,200	310	2,585
2.4	210	2,090	1,039	.....	.....	.....	4,800	26	45	1,300	360	2,780
2.5	230	2,215	1,130	.....	.....	.....	4,900	30	65	1,410	420	2,975
2.6	255	2,340	1,221	.....	.....	.....	5,000	34	85	1,540	485	3,170
2.7	280	2,465	1,312	.....	.....	.....	5,150	38	105	1,680	555	3,365
2.8	310	2,590	1,403	.....	.....	.....	5,300	43	130	1,825	630	3,560
2.9	345	2,715	1,494	.....	.....	.....	5,450	49	155	1,975	705	3,755
3.0	380	2,840	1,585	.....	.....	.....	5,600	55	180	2,125	780	3,950
3.1	420	2,970	1,676	.....	.....	.....	5,800	61	210	2,275	856	4,160
3.2	465	3,100	1,767	.....	.....	.....	6,000	67	245	2,425	932	4,370
3.3	515	3,230	1,858	.....	.....	.....	6,200	74	280	2,575	1,008	4,580
3.4	570	3,360	1,949	.....	.....	.....	6,400	81	325	2,725	1,084	4,820
3.5	630	3,495	2,040	.....	.....	.....	6,600	88	370	2,875	1,160	5,060
3.6	695	3,630	2,131	128	.....	.....	6,800	95	420	3,025	1,236	5,300
3.7	765	3,765	2,222	146	.....	.....	7,000	102	470	3,175	1,312	5,575
3.8	845	3,900	2,313	167	.....	.....	7,250	109	525	3,325	1,388	5,850
3.9	935	4,040	2,404	190	.....	.....	7,500	116	580	.....	1,464	6,125
4.0	1,020	4,180	2,495	216	.....	.....	7,750	124	640	.....	1,540	6,400
4.2	1,202	4,460	2,677	287	.....	.....	8,300	140	780	.....	1,692	7,000
4.4	1,384	4,750	2,859	390	.....	.....	8,900	156	920	.....	1,844	7,600
4.6	1,566	5,040	3,041	510	330	.....	9,550	173	1,060	.....	1,996	8,320
4.8	1,748	5,340	3,223	652	370	.....	10,250	194	1,210	.....	2,148	9,060
5.0	1,930	5,650	3,405	812	437	.....	10,950	219	1,370	.....	2,300	9,800
5.2	.....	5,970	3,587	972	533	.....	11,650	247	1,530	.....	2,452	10,540
5.4	.....	6,300	3,769	1,132	690	.....	12,400	275	1,690	.....	2,604	11,280
5.6	.....	6,640	3,951	1,292	850	.....	13,200	303	1,860	.....	2,756	12,020
5.8	.....	.....	4,133	1,454	1,010	.....	14,000	.....	2,030	.....	2,908	12,760
6.0	.....	.....	4,315	1,616	1,170	.....	14,820	.....	2,210	.....	3,060	13,500
6.2	.....	.....	4,497	1,780	1,330	.....	15,720	.....	2,390	.....	3,218	14,240
6.4	.....	.....	4,679	1,950	1,490	.....	16,660	.....	2,575	.....	3,376	14,980
6.6	.....	.....	.....	2,120	1,650	72	17,600	.....	2,766	.....	3,534	15,720
6.8	.....	.....	.....	2,290	1,810	100	18,540	.....	2,958	.....	3,692	16,460
7.0	.....	.....	.....	2,460	1,970	130	19,480	.....	3,150	.....	3,850	17,200
7.2	.....	.....	.....	2,630	2,130	170	20,420	.....	.....	.....	.....	17,940
7.4	.....	.....	.....	2,800	2,290	210	21,360	.....	.....	.....	.....	18,680
7.6	.....	.....	.....	2,970	2,450	250	22,300	.....	.....	.....	.....	19,420
7.8	.....	.....	.....	3,140	.....	295	23,240	.....	.....	.....	.....	.....
8.0	.....	.....	.....	3,310	.....	345	24,180	.....	.....	.....	.....	.....
8.5	.....	.....	.....	.....	.....	470	26,530	.....	.....	.....	.....	.....
9.0	.....	.....	.....	.....	.....	595	28,880	.....	.....	.....	.....	.....
9.5	.....	.....	.....	.....	.....	730	31,230	.....	.....	.....	.....	.....
10.0	.....	.....	.....	.....	.....	880	33,580	.....	.....	.....	.....	.....

Rating tables for stations in Idaho, Washington, Montana, and Oregon.

[Number in box head refers to page in Water-Supply and Irrigation Paper No. 38.]

Gage height in feet.	Discharge in second-feet.											
	359. Weiser River at Weiser, Idaho.	360. Palouse River at Hooper, Washington.	362. Big Blackfoot River at Bonner, Montana, Jan. 1 to June 30.	362. Big Blackfoot River at Bonner, Montana, July 1 to Dec. 31.	363. Rattlesnake Creek at Missoula, Montana.	364. Missoula River at Missoula, Montana, rod No. 3.	368. Bitterroot River at Missoula, Montana.	369. Spokane River at Spokane, Washington.	372. Naches River at North Yakima, Washington.	373. Yakima River at Union Gap, Washington.	375. Yakima River at Kiona, Washington.	376. Umatilla River at Gibbon, Oregon.
0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	56
0.1	.....	.....	720	.....	.....	.....	.....	.....	.....	.....	.....	65
0.2	.....	.....	740	.....	.....	.....	.....	.....	.....	.....	.....	74
0.3	.....	.....	760	.....	.....	.....	.....	.....	.....	.....	.....	83
0.4	.....	.....	780	.....	.....	.....	.....	.....	.....	.....	.....	92
0.5	75	.....	800	865	.....	.....	.....	.....	.....	.....	.....	106
0.6	105	.....	825	890	.....	.....	.....	.....	.....	.....	.....	124
0.7	140	.....	850	940	.....	.....	.....	.....	.....	.....	.....	146
0.8	175	.....	875	990	.....	.....	.....	.....	.....	.....	.....	172
0.9	215	.....	900	1,050	.....	.....	.....	.....	.....	.....	.....	202
1.0	260	.....	950	1,110	.....	.....	.....	1,341	.....	.....	.....	233
1.1	310	.....	1,000	1,170	.....	.....	.....	1,474	.....	.....	.....	264
1.2	360	.....	1,060	1,240	.....	.....	910	1,611	.....	.....	.....	298
1.3	415	.....	1,120	1,310	.....	.....	950	1,752	.....	.....	.....	334
1.4	470	20	1,185	1,380	.....	.....	1,010	1,897	.....	.....	.....	372
1.5	530	22	1,250	1,460	.....	.....	1,080	2,046	.....	.....	.....	412
1.6	595	26	1,340	1,540	.....	.....	1,165	2,199	.....	.....	.....	454
1.7	660	32	1,440	1,630	.....	.....	1,255	2,356	.....	.....	.....	498
1.8	730	40	1,550	1,720	.....	.....	1,350	2,517	.....	.....	.....	544
1.9	800	50	1,670	1,820	.....	.....	1,445	2,682	.....	.....	.....	592
2.0	875	61	1,800	1,930	.....	.....	1,540	2,851	.....	.....	.....	642
2.2	1,025	86	2,050	2,160	.....	.....	1,730	3,201	.....	.....	.....	748
2.4	1,200	115	2,305	2,430	40	.....	1,930	3,566	.....	.....	.....	862
2.6	1,385	148	2,575	2,730	49	.....	2,160	3,946	.....	.....	.....	984
2.8	1,580	185	2,860	3,050	62	.....	2,410	4,340	.....	.....	.....	1,114
3.0	1,780	226	3,180	3,370	87	.....	2,680	4,749	.....	.....	.....	1,252
3.2	2,000	271	3,540	3,690	120	.....	2,960	5,172	.....	.....	.....	1,398
3.4	2,220	320	3,925	4,040	163	1,600	3,260	5,609	.....	.....	.....	1,552
3.6	2,450	377	4,400	4,450	220	1,800	3,570	6,059	.....	.....	566	1,714
3.8	2,690	446	4,900	4,900	295	2,000	3,890	6,523	.....	.....	663	1,884
4.0	2,940	525	5,400	5,400	385	2,240	4,230	7,000	.....	600	780	2,061
4.2	3,200	620	5,904	.....	490	2,500	4,600	7,489	.....	800	917	2,245
4.4	3,460	735	6,408	.....	623	2,800	5,000	7,990	.....	1,000	1,074	2,435
4.6	3,720	866	6,912	.....	777	3,100	5,440	8,503	.....	1,240	1,252	2,633
4.8	3,980	998	7,416	.....	931	3,500	5,910	9,028	.....	1,480	1,468	2,839
5.0	4,240	1,130	7,920	.....	1,085	3,900	6,400	9,565	.....	1,730	1,705	3,052
5.2	4,500	1,262	8,424	.....	1,239	4,400	6,930	10,114	.....	2,000	1,962	3,272
5.4	4,760	1,394	8,928	.....	1,393	4,900	7,500	10,673	.....	2,300	2,240	3,498
5.6	5,020	1,526	9,432	.....	1,547	5,400	8,100	11,243	500	2,600	2,534	3,730
5.8	5,280	1,658	9,936	.....	1,701	6,000	8,700	11,824	700	2,900	2,842	3,970
6.0	5,540	1,790	10,440	.....	1,855	6,600	9,300	12,416	950	3,200	3,160	4,217
6.2	5,800	1,922	10,944	.....	2,009	7,300	9,900	13,019	1,200	3,500	3,490	.....
6.4	6,060	2,054	11,448	.....	.....	8,000	10,500	13,631	1,500	3,900	3,834	.....
6.6	6,320	2,186	11,952	.....	.....	8,700	11,100	14,253	1,800	4,300	4,190	.....
6.8	6,580	2,318	12,456	.....	.....	9,400	11,700	14,885	2,150	4,750	4,556	.....
7.0	.....	2,450	12,960	.....	.....	10,200	12,300	15,525	2,500	5,200	4,935	.....
7.5	.....	2,780	14,220	.....	.....	12,200	14,075	17,160	3,450	6,650	5,935	.....
8.0	.....	3,110	15,480	.....	.....	14,700	16,000	18,845	4,550	8,400	6,995	.....
8.5	.....	3,440	16,740	.....	.....	17,200	18,150	20,577	5,800	10,150	8,120	.....
9.0	.....	3,770	18,000	.....	.....	20,200	20,500	22,351	7,300	12,030	9,320	.....
9.5	.....	4,100	.....	.....	.....	24,000	23,050	24,165	8,800	14,180	10,614	.....
10.0	.....	4,430	.....	.....	.....	28,350	25,900	26,012	.....	16,510	12,045	.....
11.0	.....	5,090	.....	.....	.....	.....	33,500	29,787	.....	21,690	15,045	.....
12.0	.....	5,750	.....	.....	.....	.....	42,250	33,653	.....	27,500	18,045	.....
13.0	.....	6,410	.....	.....	.....	.....	.....	.....	.....	.....	21,045	.....
14.0	.....	7,070	.....	.....	.....	.....	.....	.....	.....	.....	24,045	.....

Rating tables for stations in Oregon, Washington, and California.

[Number in box head refers to page in Water-Supply and Irrigation Paper No. 38 or No. 39.]

Gage height in feet.	Discharge in second-feet.											
	377. Deschutes River at Moro, Oregon.	380. Hood River at Tucker, Oregon.	381. White River at Buckley, Washington.	383. Dungeness River at Dungeness, Washington.	384. Elwha River at McDonald, Washington.	386. Cedar River at Forks, Washington.	386. Soleduck River at Quillayute, Washington.	387. Sacramento River at Jellys Ferry, California.	391. Stanislaus River at Oakdale, California.	393. Tuolumne River at Lagrange, California.	396. San Joaquin River at Herndon, California.	405. Kings River at Red Mountain, California.
0.0						130						
0.2						180						
0.4						230						
0.6						286						
0.8						348						
1.0	5,000		900			410						
1.2	5,100		930			474	220					
1.4	5,200		980		485	538	260					
1.6	5,330	486	1,070		510	604	310					
1.8	5,500	560	1,225		550	672	360					
2.0	5,750	642	1,500		615	740	420					
2.2	6,240	732	1,900		710	816	490				60	
2.4	6,800	830	2,300	186	840	892	560				100	
2.6	7,360	936	2,700	190	1,000	974	630				170	
2.8	7,920	1,050	3,100	197	1,165	1,062	700				280	
3.0	8,480	1,172	3,500	205	1,345	1,150	770				445	
3.2	9,040	1,302	3,900	220	1,535	1,254	850				640	
3.4	9,600	1,440	4,300	255	1,725	1,358	930			0	850	
3.6	10,160	1,586	4,700	310	1,920	1,472	1,010			15	1,060	180
3.8	10,720	1,730	5,100	382	2,120	1,596	1,090			45	1,285	250
4.0	11,280	1,900	5,500	480	2,320	1,720	1,180	2,400		85	1,520	320
4.2	11,840	2,110	5,900	585	2,520	1,876	1,270	2,670	50	140	1,765	400
4.4	12,400	2,360	6,300	700	2,720	2,032	1,360	2,970	90	250	2,030	480
4.6	12,960	2,550	6,700	820	2,920	2,212	1,460	3,290	175	410	2,315	572
4.8	13,520	2,850	7,100	940	3,120	2,416	1,570	3,630	265	570	2,620	676
5.0	14,080	3,150	7,500	1,060	3,320	2,620	1,690	3,980	370	750	2,940	780
5.2		3,450	7,900	1,180	3,520	2,880	1,810	4,360	485	950	3,275	908
5.4		3,750	8,300	1,300	3,720	3,226	1,940	4,760	620	1,180	3,620	1,036
5.6		4,050	8,700	1,420	3,920	3,536	2,080	5,170	760	1,440	3,985	1,170
5.8		4,350	9,100	1,540	4,120	3,808	2,240	5,590	900	1,740	4,370	1,310
6.0		4,650	9,500	1,660	4,320	4,080	2,400	6,030	1,045	2,080	4,775	1,450
6.5		5,400		1,960	4,820	4,760	2,810	7,265	1,450	3,100	5,850	1,930
7.0		6,150		2,260	5,320	5,440	3,260	8,630	1,925	4,320	7,090	2,450
7.5		6,900		2,560	5,820	6,120	3,760	10,100	2,450	5,760	8,410	3,120
8.0		7,650		2,860	6,320	6,800	4,260	11,600	3,020	7,400	9,730	3,920
8.5		8,400		3,160	6,820	7,480	4,760	13,100	3,625	9,000	11,060	4,870
9.0		9,150		3,460	7,320	8,160	5,260	14,600	4,250	10,600	12,400	6,000
9.5		9,900			7,820	8,840	5,760	16,100	4,887	12,200	13,750	7,800
10.0		10,650			8,320	9,520	6,260	17,600	5,526	13,800	15,110	8,800
11.0		12,150				10,880	7,260	20,800	6,800	17,000		11,800
12.0							8,260	24,400	8,075	20,200		14,800
13.0							9,260	28,400	9,350	23,400		17,800
14.0								32,400	10,625			20,800
15.0								36,800	11,900			
16.0								41,600	13,175			
17.0								46,600				
18.0								52,300				
19.0								58,200				
20.0								64,200				
22.0								76,800				
24.0								90,000				
26.0								103,200				
28.0								116,400				
30.0								129,600				
32.0								142,800				
34.0								156,000				

[a] Continued: Gage height −0.1, discharge 105; gage height −0.2, discharge 80; gage height −0.3, discharge 60; gage height −0.4, discharge 40; gage height −0.5, discharge 30; gage height −0.6, discharge 20; gage height −0.7, discharge 10.

ERRATA IN VARIOUS PUBLICATIONS.

In preparing for publication the results of field work for 1899 frequent reference has been made to earlier publications and a number of errors have been discovered. Some of these are of relatively little importance, but they are noted in the interest of accuracy. The following list gives corrections which can be made in various Annual Reports and in Water-Supply and Irrigation Papers.

Water-Supply and Irrigation Paper No. 15:

Page 51, tenth line from bottom, for 20 miles read 11 miles.

Page 85, in table of daily gage heights, May 25, for 7.72 read 4.72.

Water-Supply and Irrigation Paper No. 16:

Page 190, in table of daily gage heights, December 23 and 24, for 2.11 read 2.92.

Water-Supply and Irrigation Paper No. 33:

Page 62, third line from top, for 57 cubic yards read 5.7 cubic yards.

Page 65, eleventh line from top, for 206,000 read 119,000.

Page 65, nineteenth line from top, for 344,398 read 344,308.

Water-Supply and Irrigation Paper No. 36:

Page 107, third line from top, for Danville read Clarksville.

Eighteenth Annual Report, Part IV:

Page 19, ninth line from top, for Conoloway Creek, read Tonoloway Creek.

Page 30, in list of discharge measurements, March 25, 1895, under area of section, for 10,524 read 6,257; July 10, 1895, under area of section, for 4,695 read 4,118; for November 16, 1895, read November 6, 1895.

Page 39, fifth line from top, before Staunton insert Natural Bridge.

Page 43, in list of discharge measurements, deduct 0.53 from all gage heights for 1896.

Page 45, in list of discharge measurements, under gage heights, for 0.07 read −0.07; for 3.43 read 1.37; for 3.20 read 0.97; for 4.70 read 2.06; for 2.00 read 0.04.

Page 65, drainage area of Catawba River at Catawba, North Carolina, for 3,402 read 1,535.

Page 113, last three lines, the description of the bench marks refers to the Alderson, West Virginia, station, and not to the Fayette, West Virginia, station.

Page 119, twenty-eighth line from top, for Como read Cowee.

Page 221, in rating table for Kansas River for 1895, opposite gage height 2.60, for 9,440 read 9,340.

Page 283, at top of page, drainage area of Piedra River, for 650 read 670.

Page 351, in list of discharge measurements, under gage height, opposite August 7, 1896, for 1.45 read 1.92.

Page 368, shift all figures at bottom of diagram one space to the left.

Nineteenth Annual Report, Part IV:

Page 319, middle of page, drainage area of Boulder Creek, for 102 read 179.

Page 333, last line of text, for Middle Loup River read Loup River.

Page 349, in footnote, for 1896 read 1895.

Page 514, fig. 184, the February flood should reach to 13,200.

Page 515, in table of estimated monthly discharge of San Joaquin River, the minimum for December 80 should read 535, and the minimum for the year should read 105 instead of 60.

Twentieth Annual Report, Part IV:

Page 165, the figures on the left of the hydrograph for Savannah River, except 0, should be moved up one division. Insert 5,000 opposite the first division.

Page 211, the figures on the left of the hydrograph for Tennessee River should all be multiplied by 10.

Page 286, middle of page, drainage area of Boulder Creek, 102 square miles should read 179 square miles.

Page 410, sixteenth line from bottom, for 402 read 404.

Page 485, footnote refers to measurements in table on ninth and second lines from bottom only.

INDEX TO PAPERS NOS. 35 TO 39.

he Water-Supply and Irrigation Papers are limited by law to 100 pages each. It was therefore ecessary to divide the report on the operations at river stations for 1899 into five parts. 'aper No. 35 contains pages 1 to 100; Paper No. 36, pages 101 to 198; Paper No. 37, pages 199 to 98; Paper No. 38, pages 299 to 398; Paper No. 39, pages 397 to 471.]

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1895.

[illegible]enth Annual Report of the United States Geological Survey, 1894–95, Part II, Papers of an economic character, 1895; octavo, 548 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the remaining public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

[illegible]ological reconnaissance of northwestern Wyoming, by George H. Eldridge, 1894; octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Bighorn Range and Bighorn Basin, especially with reference to the coal fields and considerations from the water supply and agricultural possibilities.

[illegible]rt of progress of the division of hydrography for the calendar years 1893 and 1894, by F. H. Newell, 1895; octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of work in a number of projects in western Nebraska, western Kansas and eastern Colorado.

1896.

[illegible]eenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography; 1896; octavo, 861 pp.

Contains papers on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett; and "Preliminary report on the artesian waters of a portion of the Dakotas," by N. H. Darton.

[illegible]shwell prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 228 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and includes data relating to some of the deep wells.

[illegible]rt of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 356 pp. Bulletin No. 145 of the United States Geological Survey; price, 35 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

[illegible]ifteenth Annual Report of the United States Geological Survey, 1893–94, Part IV, Hydrography; 1897; octavo, 720 pp.

Contains a "Report of progress of stream measurements for the calendar year 1894," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "Underground waters in well boring and irrigation in South Dakota," by N. H. Darton; and "Observations for irrigation," by J. D. Schuyler.

1899.

[illegible]ixteenth Annual Report of the United States Geological Survey, 1894–95, Part IV, Hydrography; 1899; octavo, 814 pp.

Contains a "Report of progress of stream measurements for the calendar year 1895," by F. H. Newell and others; "The lost rivers of Ohio," by Edward Orton; and "A preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian," by N. H. Darton.

1900.

[illegible]eventeenth Annual Report of the United States Geological Survey, 1895–96, Part IV, Hydrography; 1900; octavo, 693 pp.

Contains a "Report of progress of stream measurements for the calendar year 1896," by F. H. Newell, and "Hydrography of Nicaragua," by A. P. Davis.

Water-Supply and Irrigation Papers, 1896–1899.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of them, with other information, is given on the reverse of the last page of this cover.

[illegible]ery bulletin can be obtained only by prepayment of cost, as noted above. [illegible]y should be transmitted by postal money order or express order, made payable [illegible] Director of the United States Geological Survey. Postage stamps, checks, [illegible]ftsills can not be accepted. Correspondence relating to the publications of [illegible]rvey should be addressed to The Director, United States Geological Survey, [illegible]hington, D. C.

[illegible]
14. New tests of pumps and water lifts used in irrigation, by [illegible]
15. Operations at river stations, 1897, Part I, 1898.
16. Operations at river stations, 1897, Part II, 1898.
17. Irrigation near Bakersfield, California, by [illegible] Grunsky, 1898.
18. Irrigation near Fresno, California, by C. E. Grunsky, 1898.
19. Irrigation near Merced, California, by C. E. Grunsky, 1898.
20. Experiments with windmills, by Thomas O. Perry, 1898.
21. Wells of northern Indiana, by Frank Leverett, 1898.
22. Sewage irrigation, Part II, by George W. Rafter, 1898.
23. Water right problems in the Highwater Mountains, by Elwood M[illegible]
24. Water resources of the State of New York, Part I, by George W[illegible]
25. Water resources of the State of New York, Part II, by George W[illegible]
26. Wells of northern Indiana (continuation of No. 21), by Frank [illegible]
27. Operations at river stations, 1898, Part I, 1898.
28. Operations at river stations, 1898, Part II, 1898.
29. Wells and windmills in Nebraska, by Erwin Hinckley Barbour, [illegible]
30. Water resources of the Lower Peninsula of Michigan, by Alfred [illegible]
31. Lower Michigan mineral waters, by Alfred C. Lane, 1899.
32. Water resources of Puerto Rico, by H. M. Wilson, 1900.
33. Storage of water on Gila River, Arizona, by J. B. Lippincott, [illegible]
34. Geology and water resources of southeastern S. Dak., by J. E. [illegible]
35. Operations at river stations, 1899, Part I, 1900.
36. Operations at river stations, 1899, Part II, 1900.
37. Operations at river stations, 1899, Part III, 1900.
38. Operations at river stations, 1899, Part IV, 1900.
39. Operations at river stations, 1899, Part V, 1900.

In addition to the above, there are in various stages of preparation [illegible] relating to the measurement of streams, the storage of water, the [illegible] flow from underground sources, the efficiency of windmills, the cost of [illegible] other details relating to the methods of utilizing the water resources [illegible] Provision has been made for printing these by the following clause [illegible] sixth act making appropriations for the year 1896–97:

Provided, That hereafter the reports of the Geological Survey to [illegible] nature of streams and to the methods of utilizing the water [illegible]

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

RRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 40

THE AUSTIN DAM.—TAYLOR

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

IRRIGATION REPORTS.

The following list contains titles and brief descriptions of the principal r relating to water supply and irrigation prepared by the United States Geol Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 1

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States G ical Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, liminary report on the organization and prosecution of the survey of the arid la purposes of irrigation, and report of work done during 1889.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo, 3

Published as Part II, Irrigation, of the Eleventh Annual Report of the United Geological Survey, 1889-90. Contains a description of the hydrography of the arid and of the engineering operations carried on by the Irrigation Survey during 1890; a statement of the Director of the Survey to the House Committee on Irrigation, and papers, including a bibliography of irrigation literature. Illustrated by 29 plates figures.

Third Annual Report of the United States Irrigation Survey, 1891; octavo, 37

Printed as Part II of the Twelfth Annual Report of the United States Geological Su 1890-91. Contains "Report upon the location and survey of reservoir sites during the year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid region F. H. Newell; "Irrigation in India," by Herbert M. Wilson. Illustrated by 93 plate 190 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepar F. H. Newell; quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigatio Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Ir tion in Washington.

1892.

Irrigation of western United States, by F. H. Newell: extra census bulletin 23, September 9, 1892; quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated the total area and average size of irrigated farms in the subhumid regions, the number of farms irrigated, character of crops, value of irrigated lands, of irrigation, the investment and profits, together with a resume of the a description of irrigation by artesian wells. Illustrated by color of maps showing location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891-92, III, Irrigation, 1893; octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "An irrigation engineering" and "Engineering results of the Irrigation Survey," by H. M. Wilson; "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure and the drainage basin of Yakima River and the great plains of the Columbia River, area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States, area irrigated, cost of works, their value and profits; also describes the water supply, value of water, of artesian wells, reservoirs, and other details. Then takes up each State and Territory in order, giving a general description of the condition of irrigation, and discusses the physical conditions and local peculiarities of each State.

Fourteenth Annual Report of the United States Geological Survey, 1892-93, in parts: Part II, Accompanying papers, 1894; octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W. M. "Natural mineral waters of the United States," by A. C. Peale; "Results of irrigation measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover)

DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 40

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

J. C. Branner

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

THE AUSTIN DAM

BY

THOMAS U. TAYLOR

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, September 20, 1900.

SIR: I have the honor to transmit herewith a manuscript prepared y Prof. Thomas U. Taylor, of the University of Texas, upon the ustin dam, for publication in the series of papers upon water supply nd irrigation. This relates to a project which in many ways is of reat interest to engineers, investors, and citizens having to do with ater-power and irrigation projects. There are many useful lessons) be drawn from the history of such an enterprise, for it often appens that failure is more instructive than success. Throughout ie United States many communities are now discussing the utiliza-on of water power for irrigation or other industrial purposes, and iey may be saved from mistakes or be led to adopt precautionary ieasures by a clear understanding of the causes of the disasters which ave occurred from the neglect of certain precautions.

In this paper the author describes the preliminary projects, the onstruction of the dam, the difficulties encountered, the silting up f the storage reservoir, and, finally, the failure of the structure nd the probable causes which led to the catastrophe. The attempt made to present these facts from the engineering standpoint and ithout unduly reflecting upon the motives or characteristics of the idividuals concerned. The object is simply to state the facts as iey are understood, so that they may be available to persons who are iterested in projects of this character.

The necessity of water conservation is so great and public appre-iation of the matter has reached such a point that the construction f large dams will undoubtedly be entered upon in various parts of ie country, notably in the arid region of the West. There are many laces where such structures will without doubt be successful, and iere are other cases where the situation must be studied with ex-eme care and where great caution must be exercised in the prepa-ation of plans and in the selection of locations. The attitude most) be feared is that sometimes adopted by a community where, after iscussing the benefits of water conservation, the public as a whole ecomes convinced of its importance, and in a condition of excitement

incurs large debts, usually in the form of bonds, to push forward some project not sufficiently matured. The eagerness to attain results leads the people to disregard or pass lightly over the warnings of the engineers or their requests to be given sufficient time to thoroughly work up all of the preliminary information. The public applauds the sentiment of building the structure first and making the plans afterwards, forgetting that the structure is to last an indefinite time, and that a slight error at the outset, due to lack of knowledge, may subject the community to enormous and useless expenditures of money or result in loss of property and life. This is not an imaginary condition, for at the present time several cities or counties of the West are in the position in which the city of Austin was at the time of the adoption of the water-power project. They are urging immediate construction in order to reap the benefit during this time of drought, and are inclined to treat with disdain any intimation that their knowledge of the water supply, of the amount of silt brought down by the stream, and of the character of the foundation of the dam is too vague to justify the incurrence of an enormous debt.

It is for these reasons that this paper is offered for publication. It will serve to answer many of the inquiries made from various parts of the country and to emphasize the importance and practical application of the work of this division of the United States Geological Survey.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

A. VIEW OF DAM LOOKING EAST TOWARD POWER HOUSE.

B. VIEW OF DAM LOOKING WEST FROM POWER HOUSE

THE AUSTIN DAM.

By THOMAS U. TAYLOR.

INTRODUCTION.

Austin, the capital city of the State of Texas, is situated on Colorado River, about 200 miles from its mouth at the Gulf of Mexico. The drainage area of this river above the city is 37,000 square miles.[1] The position of the city of Austin with relation to the watershed is shown in fig. 1. This watershed extends from relatively humid regions in the vicinity of Austin westerly into the subhumid or semi-arid Staked Plains. From 1856 to 1881 and from 1885 to 1899, inclusive, a period of forty-one years, the rainfall at Austin averaged 32.52 inches, as is shown by the table on page 32. The rainfall over the entire watershed may be assumed to be about two-thirds of this, or approximately 20 inches annually.

A water power was created on Colorado River a short distance above the city of Austin, as related in the following pages. After the dam was completed the project was found to be only partially successful, as the amount of water in Colorado River fell far short of the original predictions. There was at the inception a lack of hydrographic knowledge, especially in regard to the minimum flow of the river, and other information, now known to be vital to the proper location of the dam, was not obtained. Finally, during the great flood of April 7, 1900, the dam was destroyed, with great loss of life and property.

From measurements taken in March, 1890, it was concluded that the minimum flow of Colorado River was 1,000 cubic feet per second. Upon this basis, and upon the assumption that this minimum flow would be held back nights and Sundays and utilized only sixty hours a week, it was concluded that the flow over the Austin dam would develop more than 14,000 horsepower. The city's demands were placed at 2,000 horsepower, and it was the intention to sell to manufacturers the surplus of 12,000 horsepower.

On May 28, 1896, when power was being furnished for pumping, for city lighting, and for city motors, the level of Lake McDonald

[1] The Colorado River of Texas should not be confused with the Colorado River of the West, which is formed by the junction of the Grand and Green rivers in eastern Utah, flows southerly through gigantic canyons, and finally empties into the Gulf of California.

sank below the crest of the dam and remained below until July 6, reaching its minimum (5.7 feet below the crest) on July 1. It was also below the crest from August 6 to August 25 and from September 10 to September 22. This condition was sufficient evidence that the minimum flow could not furnish even 900 horsepower, while 5,227 horsepower had been counted upon. It was apparent that much of the inflow was lost by evaporation, the area exposed to evaporation being 3 square miles and the low level occurring during the hottest part of the summer.

Notwithstanding this evidence that the river could not, during certain seasons, furnish power for its existing load of water, lights, and motors, early in 1897 the Rapid Transit Street Railway and the Dam and Suburban Railway were added to the list of power consumers. After that the energy developed by the water power was

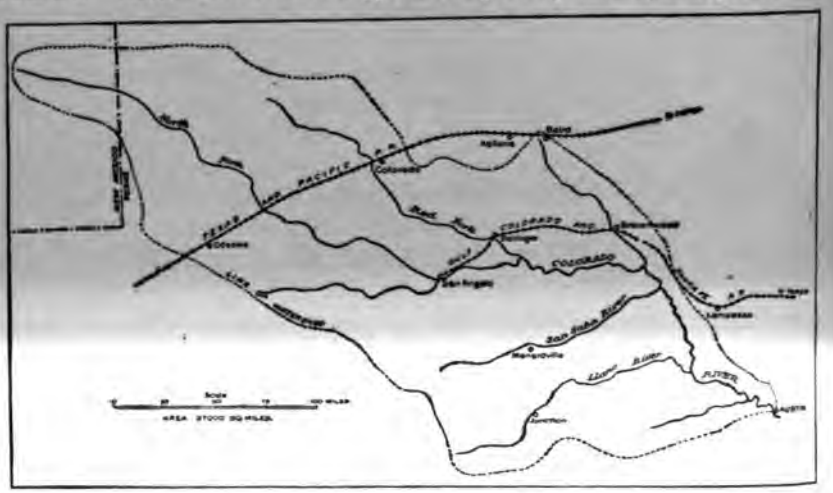


FIG. 1.—Watershed of Colorado River above Austin, Texas.

utilized (1) in pumping water, (2) in furnishing light to city and citizens, (3) in running the Rapid Transit Street Railway, (4) in running the Dam and Suburban Railway, and (5) in running the motors of various users of power in the city—such as for planers, printing presses, etc. To supply all of these demands required a total average of 1,000 horsepower.

On July 4, 1897, the water again dropped below the crest of the dam, but it flowed over again on July 17. It was also below a few days in August, October, and November, and the whole of December. On January 1, 1898, the water was 2.3 feet below the crest, and it did not again flow over until April 13. The lake level was below the crest part of the months of August and September, and it again dropped below on October 10 and continued below until April 20, 1899, reaching a depth of 10.68 feet below crest on March 29. From March 15 to April 17 it was more than 10 feet below the crest. It again dropped

elow the crest on August 9, and remained below until October 29, eaching a maximum of 10.45 feet below on October 3. Thus during he year 1899 the water was below the crest of the dam one hundred nd ninety-one days, during seventy of which the lake level was more han 10 feet below the crest, and during one hundred and sixty-seven t was more than 5 feet below. The evidence was abundant and unmisakable that the flow was not sufficient to carry the city water supply, he street lighting, the street-car systems, and the motors used in the ity. Early in 1899 measurements were made at the head of the lake, t Marble Falls, at the forebay, at the tailrace, and at the station elow the railroad bridge. These measurements showed conclusively hat the minimum flow was less than 200 second-feet. One second-foot, with an assumed effective head of 57.5 feet and a machinery efficiency of 80 per cent, would develop 5.227 horsepower, showing that an average minimum flow of 192 second-feet would be required to produce 1,000 horsepower, not taking into account evaporation and the leaks through the head-gate masonry ("spring"), which would increase the amount. Again, when the lake level fell more water would be required to develop the same power. When the level was 10 feet below the top, 1 second-foot would develop only 4.3 horsepower; and it is highly probable that the efficiency of the machinery was not as high as 80 per cent.

The result was that the enterprise proved disappointing to a large proportion of the citizens. It is true that it had long been before the people, in an indefinite way, but there was not sufficient data at hand to make the results certain. The watershed and rainfall were rather accurately ascertained; but the keystone of the whole project, the biggest and controlling factor, the very life blood of the system, namely, the minimum flow of the river, was overestimated. The feasibility of the enterprise had been demonstrated more than ten years before, and during the interval accurate and reliable data could have been obtained and the minimum flow ascertained with accuracy. Gage heights, rating tables, and flow curves could have been obtained for one-tenth of one per cent of the outlay.

It was found that the minimum flow could be relied upon to furnish water and lights for the citizens and very little more. It was of great value to the city, from a sanitary point of view, that there was during all these years a private water company, whose plant was operated by steam, supplying water and lights to the citizens.

The history of this dam is unique in one respect, and that is in the number of engineers connected with it. Early in 1892 Mr. Joseph P. Frizell resigned, it is asserted, by reason of the fact that he was hampered in his work by the city authorities. Other engineers resigned for similar causes, and at one time a contractor in charge was ordered o follow the instructions of a city official who was not an engineer. This peculiar method of conducting a great public work called forth evere criticisms from engineering journals.

The failure of the dam to meet expectations and its failure structurally were due to—

(1) The lack of hydrographic knowledge, causing (*a*) an overestimate of the minimum flow, and (*b*) an underestimate of the effect of evaporation.

(2) The hampering of the engineers of construction.

(3) The ignoring of geologic formations.

PRELIMINARY PROJECTS.

Texas became an independent Republic in 1836, and a few years later a commission was appointed to consider the question of locating the capital. In their report they referred to the possibility of developing the water power of Colorado River at Austin.

Nothing was done, however, until in 1871, when Mayor Glenn had surveys made by the city engineer. It was the plan at that time to convey the waters of the Colorado, by a canal, from a point near Mount Bonnel to Shoal Creek, for city and manufacturing purposes.

In 1873 a charter was granted to certain parties, some of whom are still living, to erect a dam across the Colorado, but it was allowed to lapse by limitation.

The drought of 1877 called the attention of the public to the possibilities of irrigating the lands on Colorado River below Austin by means of a dam erected near the city.

During Governor Roberts's administration (1879–1883) estimates were made, with a view to lighting the public buildings, of the cost of erecting a dam across Colorado River at Bull Creek.

In 1888 the board of trade had surveys made for the purpose of determining the feasibility of damming the river, and during the year 1889 the subject was kept before the people by frequent communications in the newspapers.

In the latter part of 1889, the contest for mayor was largely fought on the issue of building a dam across Colorado River. The result of the election foreshadowed early action in regard to the enterprise. In February, 1890, the city council employed Mr. J. P. Frizell to make a report upon the proposed dam and the necessary adjuncts. The report was submitted on March 26, 1890, and so completely does it discuss the whole problem that the portion which refers to the project in general and the part which deals more particularly with the dam, the water power, and the estimated total cost, are here quoted, as follows:

The city is, at present, supplied by a water company, upon what is termed the Holly system; that is, without the use of a reservoir, the pressure in the pipes being maintained by the action of the pumps, which are operated by steam, and increased by an automatic device upon the occurrence of fires. The company also furnishes power for the electric-light system of the city. I have not been able to obtain any very complete information in regard to the extent and size of the present system of pipes. From what I can learn I judge that the city is rapidly *outgrowing* the capacity of the pipes. That by reason of their small size, a great *and increasing* burden is laid upon the pumps to maintain pressure sufficient for

A FRESHET FLOWING THROUGH GAP IN PARTIALLY COMPLETED DAM

B. RIVER FLOWING THROUGH MAIN GAP IN PARTIALLY COMPLETED DAM.

omestic service in remote parts of the system. A large part of the power of the umps is consumed in the friction of the water in passing through the pipes: and s the city extends and increases, the protection against fire is becoming more and ıore precarious. There is also a very widespread impression prevailing that the mount paid for water rates, fire service, and electric lighting is sufficient to supply the city on a much more ample and liberal scale, and at the same time secure ıcidental advantages of great value.

The project before the city is:

First. The construction of a massive dam across the Colorado to furnish power or pumping, for electric lighting and propelling street cars.

Second. The construction of a reservoir at a height sufficient to maintain fire reasure in the pipes.

Third. The extension of the distributing system on a scale of magnitude commensurate with the present and prospective wants of the city.

Fourth. As an incident of the project it is expected that there will remain a arge surplus of power susceptible of such uses as will greatly promote the future rosperity of the city.

THE DAM.

The Colorado above Austin flows in a deep cut or canyon worn in the limestone ock. It is skirted by limestone bluffs rising often to the height of 150 feet above he bed of the river, broken by the erosion of tributary streams. No extensive neadow or bottom lands exist. This situation permits the construction of a high lam with but little damage to private property. The river, in it normal condiion, occupies but a small part of the channel in the rock, the remainder being ccupied by alluvial deposits to the depth of average high water. In great floods he river spreads from bluff to bluff.

Several situations have been examined with reference to the construction of the lam. One on Taylor's lime chute, about 3¾ miles from the city limits, appears nost favorable to the construction of the dam itself, but one on the Brackenridge roperty, about three-fourths of a mile nearer town, possesses greater advantages as regards the canal and works appertinent to the water power. This site has een selected for the purpose of the estimate.

The channel in the rock is here about 1,150 feet wide at a height of 60 feet above he summer level of the river. The cross section of the channel is not far from evel on the bottom, and is bounded by nearly perpendicular walls of rock rising o the height of a little over 60 feet on the city side of the river and 125 or more n the other side. The river bed proper occupies not more than one-half of this vidth, the remainder of this being alluvial deposit, rising to the height of 40 or 50 eet above the river bed. The situation here is admirably well situated to the levelopment of water power by a dam about 60 feet in height, the perpendicular ace of rock rising to about that height, and thence receding from the river in gentle slope, forming a bench on which the canal or feeder could be constructed, he alluvial strip of ground between the canal and river furnishing sites for pumpng and power stations and any other establishments requiring power. An estinate has accordingly been prepared on the basis of a 60-foot dam.

Its crest will be about 1,150 feet in length [the crest was really 1,091 feet long]. t is contemplated to make it some 16 feet thick at the top, increasing downward nd spreading out in a broad toe or apron, to give the water a horizontal direcion, making its extreme width at the bottom about 50 feet. The body and pstream face of the dam to be made of limestone rock abounding in the vicinity, he upstream face being of quarry-faced work with close joints. The downtream face and toe are intended to be of granite found in abundance in Burnet ounty, split to approximately regular shape and laid with but a small amount of oling. The capping is of granite in as large blocks as can be handled, worked regular shape. The entire work to be laid in hydraulic cement.

The Colorado at Austin drains some 40,000 square miles, and, of course, carries at times an enormous flow of water. The highest flood within the memory of the people now living was some 45 feet above low water, and from the best data I can obtain the flow of the stream was some 250,000 cubic feet per second. This would imply a depth of 16 feet on the crest of the dam, and the abutments should of course go to that height. At one end of the dam the natural rock goes far above that height. The other end is occupied by an artificial bulkhead, called the gate-house, containing the sluices for drawing off the water. It is expected that the wash of the dam during floods will carry away the alluvial deposit for a considerable distance. The wheels, for this reason, must be some 200 or 300 yards from the dam, and the canal must have that length. As already stated, the formation permits this canal to be excavated in rock. At the entrance to the canal is the gate house alluded to above. Its function is to enable the water to be shut out of the canal in case of repairs and to prevent the canal from being overflowed in time of floods. The water will be drawn from the canal through iron pipes, pass the wheel, fall into the wheel pits and be discharged through underground races into the river.

WATER POWER.

It remains to consider the quantity of water power created by the proposed improvement. This consists of two elements, the fall, and the quantity of water available for power. The former is fixed approximately by the height of the dam. The latter can be inferred with more or less certainty from known facts. It is not the lowest stage that the river is ever known to attain to. It is the flow of water that can be depended on, with reasonable certainty, during ordinary seasons. Stages of the river above this minimum count for nothing unless steam is used to make up deficiencies.

The river is subject to great rises in times of heavy rains. On the cessation of the rains it falls rapidly until it attains a minimum flow, which appears to remain nearly constant. In that condition no water enters the stream from the surface of the ground. Its flow is wholly maintained by springs issuing from cavities in the rock, and is unaffected by current rainfall until the latter becomes sufficient to cause a flow from the ground. This is the present condition, and I conclude we shall not be far wrong in taking the present flow of the stream as the quantity that can be depended upon. This, as I have ascertained by careful measurement, is nearly 1,000 cubic feet per second.

There will, no doubt, be times during the hottest weather when the water will fall below this stage, on account of increased evaporation. I am told, however, that a month very rarely passes without rains in some part of the drainage basin, sufficient to cause a slight rise at Austin. The great extent of the pond will enable a considerable deficiency in the flow of the stream to be made good by storage. From the best information I can obtain, the pond will extend some 30 to 35 miles from the dam, with an average width of one-quarter of a mile, containing a water surface of some 8 square miles, and a total volume of something like 2,800,000,000 cubic feet of water. Should the flow of the stream diminish to one-half the above quantity, a single foot in depth on the pond will make good the deficiency for a period of five days, and 6 feet will make it good for thirty days.

A system of flashboards could readily be applied to hold the water 4 feet above the crest of the dam, and thus hold the surplus of water in store for such deficiencies, without drawing the pond below the crest of the dam. This feature will not become necessary for several years, and need not be considered further at present.

Owing to the imperfection of mechanism we can not hope to utilize, for practical purposes, more than 80 per cent of the absolute power of the water. Moreover, the full head of 60 feet can not be brought to act upon the wheels. Some part of the head will be consumed in the movement of the water through the sluices, canal, penstocks, and races. The head will at times be reduced by high water in the

A. CLOSING GAP IN DAM.

B. DAM NEARING COMPLETION, FEBRUARY 1893.

ver, which rises more below the dam than above. I therefore take 57½ feet as e head acting on the wheels, and assume that we can utilize 80 per cent of the ıwer on that head. This gives, for the total amount of power available for iving machinery, $\frac{57.5\times62.5\times1,000}{550}\times0.80=5,227$ horsepower.

This quantity of power could be furnished constantly, night and day. This, wever, would not be suited to the requirements of industry, which ordinarily lls for power only during the working hours of the secular day. It is regarded a great advantage in water power to be able to hold back the low-water flow of ɔ stream during nights and Sundays and use it during the working hours. This ɔ great extent of our pond readily enables us to do. Concentrating the entire ekly flow of the stream into the working hours assumed at 60 per week, the ove amount is increased in the ratio of 60 to 168, giving as the available power 636 horsepower.

The total permanent power of the Merrimac River at Lowell, Massachusetts, is t over 11,000 horsepower, on an average during working hours. About the me at Lawrence, Massachusetts, and at Manchester, New Hampshire. This is e power that can be supplied without interruption. At these points the use of ıter is not confined to the minimum flow of the stream. It is utilized at much gher stages, in connection with steam, the latter being called into use when the w diminishes. Of course similar methods will prevail here as soon as the mand for power warrants their introduction. This, however, is too remote for esent consideration.

It is not easy to state the rental received for water power at the great manu-cturing centers in New England, as grants of water are usually covered with ants of land, the water being regarded as an easement of the land. A round m was paid for the land and a nominal rent for the water, which was intended the fund for the maintenance of the appliances of the water power. When ınufacturers draw in excess of their grant they are charged all the way from $8 $12 a day for mill power for water terminable at will. My opinion is that 200 per annum fairly represents the value of a mill power. These considera-ns are adverted to as showing the great value of the incidental benefits secured the city by this improvement. The city's requirements for pumping I put at) horsepower twelve hours per day, or 720 horsepower ten hours a day. Reserv-ɡ an equal quantity for electric lighting, and equally liberal provision for street rs and other purposes, there would remain over 12,000 horsepower, or as much 180 mill powers, subject to such use as the city might deem conducive to its osperity.

ESTIMATED COST.

Dam	$463,325
Gate house	22,950
Canal	49,750
Pump and power house	3,500
Wheel pit	2,123
Culvert	10,210
Wheels and pumps	16,025
Filtering gallery	17,880
Reservoir	104,615
Mains	153,800
Distribution	295,250
Electric light	45,600
Add for contingencies	118,502
Add for engineering and agencies	59,251
Grand total	$1,362,781

On April 3, 1890, the board of public works was created by
council, to have control of the construction of the dam and of a
connected therewith.

The question of issuing water and light bonds to the am
$1,400,000 was submitted to the voters of the city of Austin
5, 1890, and resulted in 1,354 votes in favor of and 50 votes
the issue. The board of public works met the next day and er
Mr. Frizell as chief engineer and Mr. J. F. Pope as first a
engineer. In order to guard against possible errors, and to h
advantage of the skill and experience of other experts, M
Bogart, of New York, was employed as consulting engineer, to e
the site and the plans and specifications of Mr. Frizell. A

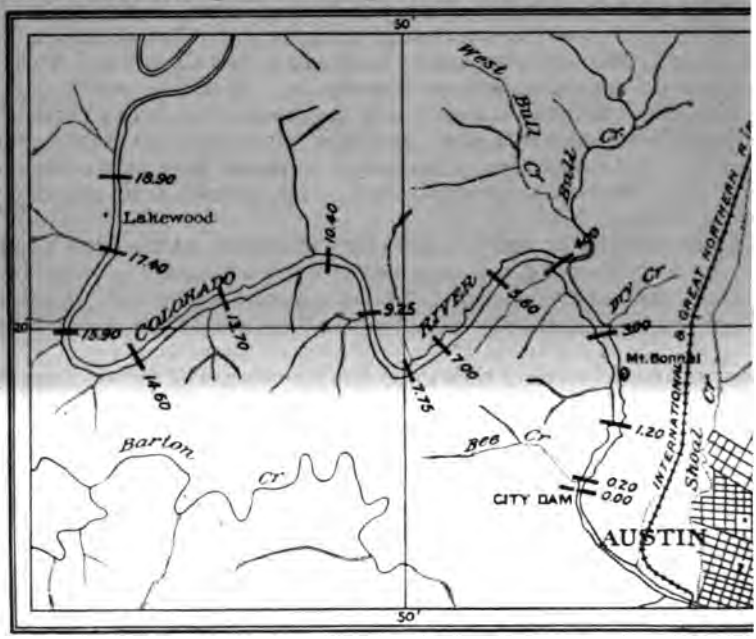


FIG. 2.—Index map of lines of soundings across Lake McDonald, above Austin, Texas is the broadened portion of Colorado River, extending from sounding 0.00 to sour created by the building of the dam.

extended examination Mr. Bogart made a written report to th
in which he stated that after considerable study he was of the
that the site selected by Mr. Frizell was the best place for the
of the dam. In regard to the cross section and shape of the d
Bogart said:

Ample precedents exist for the determination of the best lines of pr
methods of construction for such a dam. It will be one of the high dams
not be among those very high structures which sometimes excite doubt a
permanent stability. To provide for the possible height of spring or oth
the whole crest of the dam will be formed so that the water may flow ov
the downstream face will be built in such a manner and to such lines an
as will tend to conduct the overflow to the lower river without dama
stability of the structure. It is estimated that the highest flood as to w

A. HEAD-GATE MASONRY AND PENSTOCKS BEFORE MAY, 1893.

B. LAYING THE LAST STONE, MAY 2, 1893.

nformation can be obtained might give a depth of water of 15 or 16 feet over the rest for a short time. Such a possible flow will be provided for in the construction of the dam. The exact lines of the profile and the detail method of construction are now being determined in consultation with Mr. Frizell.

During the summer of 1890 engineers were put in the field to locate the lake-level contours and to determine the amount of valuable land submerged. These engineers took cross sections of the river at sixteen stations, thus enabling comparisons to be made, which was done by the writer in May, 1897, and in January, 1900. The accuracy of the work under the supervision of Mr. Pope was verified by the fact that at the head of the lake, at the request of a farmer living near, he cut a bench mark, on a big pecan tree, at the crest level. Three years later the water, when it rose to the crest of the dam, reached the notch with exactness. Cross sections of the lake are shown in fig. 6; a general map of the lake is shown in fig. 2.

CONSTRUCTION OF DAM.

On October 15, 1890, the contract for the construction of the dam was awarded to the lowest of seven bidders, Mr. Bernard Corrigan, of Kansas City, Missouri, whose figures were $501,150. The contract was based upon the following specifications:

ROCK EXCAVATION.

12. On the site of the dam all unsound rock and all rock that can be removed without blasting will be taken off. A trench 4 feet wide and as deep as may be directed by the engineer will be excavated along the upstream face of the dam. Trenches, footings, steps, channels, and other excavations will be cut in the bottom and sides of the rock in such forms and to such lines as may be directed by the engineer. In these excavations the kind of explosive used, the amount of the charges, depth and direction of the holes, and the entire process of the work shall be under the immediate personal control of the engineer or his assistant, the object being to do the work in such a manner as to avoid fissures and shakes in the remaining rock. All cracks and fissures that may exist naturally or from any cause shall be thoroughly filled with cement mortar or concrete or pure cement, as may in each case be directed by the engineer.

13. The lines and grades of the canal will be established by the engineer, and no excavation below the grade or bottom or outside the lines will be paid for; but such excavation will be permitted, under the direction of the engineer, for the purpose of obtaining rock for the dam.

14. Any rock obtained from these excavations that the engineer may deem suitable may be used in the rubble masonry of the dam. Rock not suited for this purpose will be disposed of as the engineer may direct—in spoil bank, riprap, filling of cribs, or otherwise—not involving a haul of more than 500 yards. The price of rock excavation will include and cover the cost of all the explosives, tools, derricks, tackle, machinery, teams, vehicles, tramways, stringers, bridges, boats and appliances, materials, and labor used in the excavation of the work. All rock will be measured in excavation.

MASONRY.

15. The upstream face of the dam will be laid of granite.[1] It must be sound,

[1] The original specifications called for fossiliferous limestone for the upstream face, but bids were also received for granite, which material was adopted. The details here given are obviously not proper for granite.

free from seams, cracks, and shakes. The stones will be laid on their quarry beds in regular courses, no course to be less than 12 inches in height. Each course shall be composed of headers and stretchers, and at least one-third of the face length of each course shall be headers. The headers and stretchers shall be regularly distributed in each course, so that the headers shall alternate in position in the adjacent courses and so that each stone shall break bond not less than 12 inches with the stone above and below. A gamut or plan of each course will be prepared and submitted to the engineer before the stones are laid and, if approved by him, will be used for the guidance of workmen in laying the stones. This will be quarry-faced work. Each stone will have a distinct pitch line all around the face. The bed and build joints will be fine pointed to a fair, true surface, out of wind, 9 inches back from the pitch line. The remainder of the bed and build joints to be pointed, so as not to project beyond the plane of the fair, true surface and not to fall away therefrom more than 1½ inches. The width of the stretchers on their beds will not be less than their height. No stretcher will be less than 3 feet in length. The headers will not be less than 30 inches on the face nor less than 4 feet in length. This work will be laid with full mortar joints on the beds. The mortar will be pressed or tamped into the build joints with a proper tool. After the work is laid the mortar will be raked out of all the exposed joints to a depth of 1½ inches, and these joints will be pointed with mortar of neat cement pressed in and rubbed hard.

16. In measuring this work, the headers will be accounted 4 feet long. The width of each stretcher will be considered equal to its height. No stone of less dimension will be laid. If stones are laid exceeding these dimensions the excess will be paid for as rubble filling.

17. The downstream face of the dam is to be laid with granite of good quality, sound and free from imperfections. It will be laid in regular courses; no course to be less than 12 nor over 30 inches high. Each course shall be composed of headers and stretchers, and at least one-third of the face length of each course shall be headers. The headers and stretchers to be regularly distributed in each course, so that the headers shall alternate in position in the adjacent courses, and so that no stone shall break bond less than 12 inches with the stone above and below. The stretchers to be as wide as high, measured on the lower bed. No stretcher to be less than 3 feet; no header to be less than 3 feet on the face and 4½ feet long. On the curved part of the face, except at the toe, the bed joints shall be radial. On the vertical and battered part they will be horizontal. Dowels and clamps of wrought iron will be inserted at the toe as directed by the engineer.

18. The exposed faces of all these stones are to have distinct pitch lines all around. The face not to project or recede more than 1½ inches from that line. The beds and builds to be pointed off to lay a three-fourth inch joint for 12-inch back from the pitched line.

19.[1] If this work is laid with fossiliferous marble, the specifications will be the same in every respect as for granite, except that the beds and builds will be dressed to a ½-inch joint instead of a ¾-inch joint. Bids will be received for either kind of stone. A gamut or plan of each course will be prepared as specified for the upstream face.

20. In measuring this work the headers will be taken as 4½ feet long, the stretchers as wide as high, measured on the lower bed. No dimensions less than these will be accepted. If stones of greater dimension are laid, the excess will be paid for as rubble filling. All of this work is to be laid in cement mortar.

RUBBLE MASONRY.

21. Rubble masonry will be laid in the body of the dam. This will be composed of any firm, strong, and sufficiently heavy stone. It must not weigh less than 150

[1] This paragraph is eliminated from specifications.

pounds per cubic foot. At least two-thirds of it must consist of blocks having a bed of not less than 4 square feet. Smaller stones may be used to fill up the spaces between blocks. All stones must be bedded in mortar and all interstices filled with mortar. Such practices as laying down stone and pouring grout into the cavities will not be allowed, and the inspector will require such work to be torn up and relaid whenever discovered. The rubble work will be well bonded with masonry on the up and down-stream faces. The trench along the upstream face of the dam will be filled with fragments of granite ["or fossiliferous marble," erased in specifications], of any form and size, carefully laid in cement mortar. Should distinct veins or streams of water enter this trench, the water will be allowed to rise through earthenware drain-pipes set in the masonry, or through openings left in the masonry, and discharged above the dam.

22. The capstones will be of granite of the best and soundest quality, free from all imperfections. They will be 3 feet in depth, not less than 3 feet wide, measured lengthwise of the dam, and each cap will consist of not more than three stones. The stones of the adjacent caps will break beyond 24 inches. A distinct pitched line will be cut around the weather face, following the outline of the stone, as shown on the plan. The weather face will not be more than 1 inch out as regards this line. The beds and builds will be cut to a half-inch joint, 12 inches back from this line. The stones will be bedded in mortar; the build joints will be filled with melted sulphur, of quality approved by the engineer. Dowels of wrought iron will be inserted as indicated on the plan, and also bedded in sulphur: the stones will be fastened together on the top with wrought-iron clamps and dowels, as directed by the engineer.

23. The price of masonry will include furnishing the stone, cement, and sulphur and all materials and labor required for the excavation of the work as herein provided.

24. Before commencing the laying of any masonry the rock on which it is to rest must be swept and washed clean with brooms, and the same must be done when new masonry is joined on to old. All stones must be washed before being laid in the work. A tank and other appliances satisfactory to the engineer must be provided for this purpose.

CEMENT.

25. The cement furnished for this work must be from manufacturers of established reputation, and such as has satisfactorily stood the test of time and experience. It will be subjected to such tests as the engineer may require from time to time, and such as is rejected must be immediately removed from the work. Quick-setting cement will not be used. Cement showing on chemical analysis magnesia or lime in proportions sufficient to injure the work will be rejected. American natural cement will, in general, be expected to exhibit a tensile strength of 50 pounds per square inch at the end of thirty days, when mixed with twice its bulk of sand. Portland cement will be expected to show a strength of 150 pounds per square inch at the end of thirty days when mixed with three times its volume of sand. Cement shall be stored in sheds sufficiently water-tight to exclude rain, with floors raised at least 12 inches above the ground, and permitting a free circulation of air. To give opportunity for tests the contractor shall have no less than sixty days' supply of cement on hand at all times. [Only Portland cement was used.]

MORTAR.

26. The mortar is to be prepared from cement of the quality above described and clean, sharp sand, free from loam or other impurities, in the proportion of 1 part cement to 2 of sand, by measure. If made by hand it is to be mixed dry, and

a sufficient quantity of water afterwards added to produce a paste of proper consistency, and thoroughly worked with hoes or other suitable tools. If required, the contractor shall provide a mortar mill of such form as the engineer may prescribe, to be worked by steam or horsepower. The mixing of the mortar will be under the constant supervision of an inspector. Sand offered for the work shall be washed and screened, if the engineer shall so direct, in such manner as he shall prescribe.

40. And the said contractor hereby agrees to receive the following prices as full compensation for furnishing all materials and for labor in executing all work contemplated in this contract, and for all risks of loss incident to the nature of the work, to floods and freshets on the river, or to other action of the elements, to strikes and combinations of workmen, to changes in market values during the progress of the work, and to all other causes:

(*a*) For bailing and draining, including the construction and maintenance of all necessary cofferdams, the furnishing, setting, and operating of steam engines, boilers, and pumps, and all labor and materials required for the removal and exclusion of water from the work during its entire progress, as specified, the sum of $8,000.

(*b*) For all earthwork excavation above the low-water level of the river, including the disposal of the same in spoil banks or in cofferdams, and all clearing and grubbing, the sum of 14 cents per cubic yard.

(*c*) For all earth excavation below the low-water level of the river, including the disposal of the same, the sum of 50 cents per cubic yard.

(*d*) For rock excavation on the site of the dam, including the disposal of the rock in spoil banks, riprap, or otherwise, as may be required, the sum of $1.60 per cubic yard.

(*e*) For rock excavation from the canal and site of gate house, including the disposal of the rock, the sum of 80 cents per cubic yard.

(*f*) For the masonry of the upstream face of the dam, of granite, cut and laid as specified, the sum of $11 per cubic yard.

(*g*) For the masonry of the downstream face of the dam, of granite, the sum of $11.25 per cubic yard.

(*h*) For rubble masonry laid with stone paid for as excavation, $2.50 per cubic yard.

(*i*) For rubble masonry laid with stone not paid for as excavation, the sum of $3.50 per cubic yard.

(*j*) For rubble masonry laid with granite in trenches, the sum of $6 per cubic yard.

(*k*) For the granite capstones dressed and laid as per specifications, the sum of $15 per cubic yard.

(*l*) For drilling bolt holes for wrought-iron clamps and dowels, the sum of 24 cents per linear foot of hole drilled.

(*m*) For furnishing and inserting wrought-iron clamps and dowels as required by the specifications, the sum of 10 cents per pound.

(*n*) For laying masonry of any kind in Portland cement mortar in excess of the price received for the same work laid in mortar of American natural cement, the sum of 50 cents per cubic yard. [There were more than 90,000 yards excess.]

41. And it is further agreed that the engineer shall make approximate monthly estimates of the work done, and the materials delivered, and the payments shall be made of 85 per cent only of the amount of such monthly estimates.

42. And said contractor hereby further agrees that the said board be, and is hereby, authorized to deduct and retain out of any money due the contractor the sum of $500 per day as liquidation damages for each and every day the aforesaid

work shall remain uncompleted beyond the time herein stipulated for its completion; provided, however, that the board shall have the right to extend the said time, should it decide to do so.

43. And it is further agreed that of the sum agreed on as compensation for bailing and draining, three-fourths shall be considered as earned when the entire masonry is raised to a height of 3 feet above the low-water level of the river, and the remainder when the dam is fully completed according to the terms of this contract, and that these sums shall be subject to the above-mentioned deduction of 15 per cent.

43a. The power of the board of public works and the engineer acting under them as now constituted only extends to executing the contract as it is made by the city; and all changes of the contract and final approval of work done shall be by the city council upon the recommendation of the board of public works, or by the proper city authorities that may be provided by law from time to time as the work progresses.

43b. This contract is conditioned upon a railroad being constructed by the city or some persons other than the contractor from the depots in the city of Austin to the site of the proposed dam, and the said city guarantees to the said contractor the use of the said railroad track free of charge for hauling all material for the construction of the dam. It is understood that all time which may be lost by the contractor by reason of the noncompletion of said railroad shall be credited by said contractor on the time stipulated for the completion of the dam.

The cross section originally adopted is shown in fig. 3, left half. The contractor commenced the work of excavating the alluvial soil on the east bank on November 5, 1890, and the first stone was laid in the foundation of the dam May 5, 1891, exactly one year after the election authorizing the issue of the bonds. The east half of the dam was built to a safe height above ordinary freshets, and then the work was pushed from the west end. The foundation work at the east end was protected by a natural dirt cofferdam and at the west end by a wing wall of broken limestone for body and hay and dirt as fillers. This deflected the water toward the west end of the eastern portion, and the western section of the dam was thus built out to within a short distance of the eastern portion. The gap was closed by first constructing a small dam in front of it, thus forcing the water through a gap in the eastern portion only a few feet higher than the foundation courses. In this way the water was played from one gap to the other at the pleasure of the contractor. The gaps left in the dam while the work of construction was proceeding are shown in Pls. II and III. When the courses reached a sufficient height, a framework dam was made to check the flow through the gaps. In September, 1892, three sluice pipes, each 3 feet in diameter, were built into the dam at a level 43½ feet below its crest, so that there could be no basis for complaint of stopping the flow of the river, and, incidentally, to assist the contractor in controlling the water. At a later stage of the construction one of these pipes, half open and under a head of 36.5 feet, passed the whole flow of the river.

The dam cost over $110,000 more than Mr. Corrigan's original bid. The causes of this increase were—

1. Increased excavation at east end of dam	$8,914.60
2. Extra masonry	56,793.32
3. Extra limestone masonry	21,839.80
4. Extra allowance for Portland cement	44,180.25
5. Change in shape of crest	2,337.45
6. Allowance for pumping, excavating without explosives, and cement	3,385.49
Total	137,450.91
Overestimate	27,255.62
Total extra cost	110,195.29
Original bid	501,150.00
Total cost of dam	611,345.29

The plans recommended by Mr. Frizell contemplated a canal several hundred feet long and a power house south of the site subsequently selected, located upon the alluvial soil below the dam. In January, 1892, it became manifest that some members of the board of public works did not approve the plans submitted by Mr. Frizell in so far as they related to the canal. They advocated the abolition of the canal, and suggested that the water be taken directly from the lake by the penstocks, and that the power house be located near the east end of the dam. At this juncture the board requested Mr. E. C. Geyelin, of Philadelphia, to visit Austin and report upon the questions at issue. In his report, dated February 17, 1892, Mr. Geyelin recommended, among other things, that the power house be located upon a rock foundation at least 100 feet from the dam, and that the water be conveyed from the lake by a series of large pipes. (The power house was afterwards located at an average distance of 130 feet from the dam.) Mr. Frizell took issue with these recommendations, and the board then decided to ask the advice of Mr. J. T. Fanning, of Minneapolis. After spending several weeks in Austin investigating the problems, Mr. Fanning, on June 24, 1892, submitted his report to the board, and among other things said:

This dam is being constructed of solid masonry and is faced on each side with large blocks of excellent granite. Not for its length alone or its great area of flowage is the dam remarkable, for in France we observe three longer masonry dams—at Bouzey, Chazilla, and Gros Bois, 1,545, 1,759, and 1,805 feet long, respectively—and in Wales the Vyrnwy dam, 1,350 feet long, the latter being for the storage reservoir of the Liverpool water supply.

Not in the height alone, for in France there are 3 dams, in Spain 2, in Belgium 1, and in the State of California 1 masonry dam exceeding 150 feet in height. There are 14 other notable masonry dams having heights exceeding 100 feet.

But none of these dams are upon great rivers, and very few of them have any water pass over their crest. On the other hand, the Austin dam is in the channel of the Colorado River, where it has 40,000 square miles of watershed, and will have floods of 200,000 to 250,000 cubic feet of water per second to pass from its crest to its toe. Your citizens will appreciate your responsibility when they learn

that no dam in existence has to pass a volume of water, in flood, even approximating this, through so great a height. Limestone and sandstone yield rapidly to the eroding force of falling waters. The evidences of this are abundant in the canyon of the Niagara River below Niagara Falls, in the canyon of the Genesee River below the Genesee Falls, the Mississippi River below St. Anthony Falls, and here of the Colorado River across Travis County, as well as in the channels of numerous streams that flow down each of the Rocky Mountain slopes. Such evidences admonish us that this great flood must not be permitted to have a sheer fall through so great a height and act with a destructive force such as has heretofore created canyons, but it must be made to glide down the slope of the dam and not be permitted to exert the force due to its velocity except at such distance below the dam that the foundations will not be endangered.

The profile [fig. 3, left half] as shown to me seems not to fulfill the required conditions for passing the floods, because of the slightly rounded or nearly angular form at the front of its crest. Another diagram [fig. 3, right half] presented shows an advised modification of the profile of the upper part of the dam, which is better adapted to pass the flood in a gliding sheet down the face of the dam and to deliver it to the lower level without a direct blow, and so that its velocity will

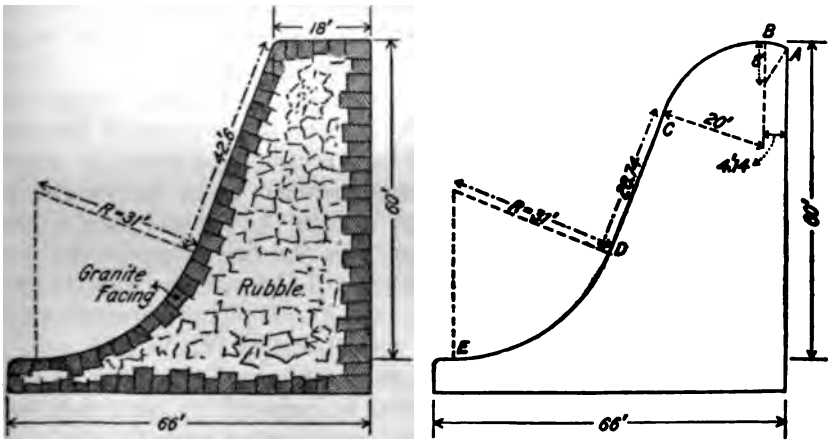


FIG. 3.—Cross sections of dam: Left side as proposed by Frizell; right side as constructed by Fanning.

be expended chiefly in a horizontal direction in the backwater below the dam and in eddies at a safer distance below the toe of the dam. The lower part of the downstream face of the dam has a curve of 31 feet radius to which low-water surface is tangent. The central part of this face has a batter of 4¼ inches to the foot.

The new profile at the top part, as suggested, completes the downstream face and crest of the dam with a curve of 20 feet radius, to which both the front batter and the surface of the pond at a level of the crest are both tangent, this curve ending on the crest at 5 feet from the upper angle of the crest. The upper angle of the crest is then rounded off with a smaller curve, and the entire front of the dam becomes a reverse curve of ogee form, the form of dam best of all adapted to pass a large volume of water through so great a height. The top curve conforms nearly to the theoretical form of a medium flood stream. At higher flood stages there will be tendency to vacuum under the curve stream immediately after it has passed the crest, which, together with the pressure of the atmosphere upon the top of the stream, will keep the full flood stream in full contact with the curved face of the dam, and cause even the highest flood to glide down the fall without shock upon the face of the dam or the soft rock foundation.

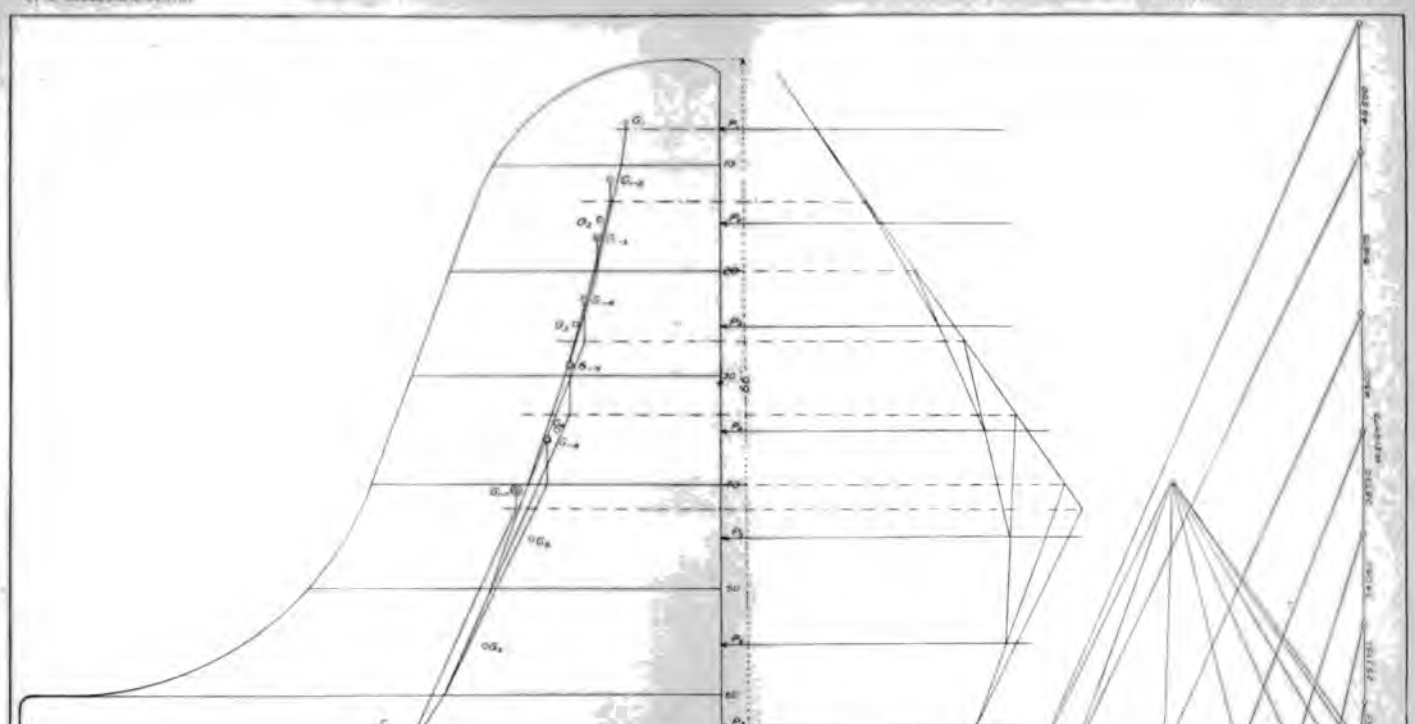
In addition to this, Mr. Fanning recommended that the power house be located in the position shown in fig. 5, and that the river side of the power house rest on a granite revetment wall 250 feet in length, to protect it from the force of the water.

The board of public works finally determined to change the cross section of the dam to that shown in fig. 3, right half, to locate the power house near the east end of the dam, and to take the water from the lake through 9-foot penstocks. The head-gate masonry before May, 1893, is shown in Pl. IV, *A*, which also illustrates the positions of the wrought-iron penstocks.

Pl. V shows the "line of resistance" of the dam, on the assumption that the masonry averages 125 pounds per cubic foot. This line of resistance falls within the middle third, and shows that the cross section was well designed to resist the pressure of the water.

To find the line of resistance of the dam, the height was divided into six equal sections of 10 feet depth, leaving the bottom or seventh section 6 feet deep. The areas of these sections were found to be 150, 235, 271, 310, 360, 495, and 396 square feet, respectively. Their centers of gravity were found and marked G_1, G_2, G_3, etc. For 1 foot in length of the dam the above areas became the volumes of the sections, in cubic feet. The weight of each section was found by multiplying the volume by 125, which was assumed to be the weight, in pounds, of a cubic foot of masonry. While the granite face of the area would have weighed more than this, the limestone cement core would have weighed less. The weights of the sections were 18,750, 29,375, 34,062, 38,750, 45,000, 61,875, and 49,500 pounds, respectively, and they will be referred to in this description as W_1, W_2, W_3, etc.

The horizontal water pressures were found to be 3,125, 9,375, 15,625, 21,875, 28,125, 34,375, and 23,625 pounds, respectively, and they will be referred to as P_1, P_2, P_3, etc. The forces acting upon the first section were the horizontal water pressure of 3,125 pounds (represented by P_1 in Pl. V) and its weight of 18,750 pounds, acting through G_1. By producing the force P_1 and W_1 to intersect, finding their resultant, and producing this resultant to cut the bed joint, we find the first point in the line of resistance. The forces acting on the first two sections were the two water pressures P_1 and P_2 (3,125 and 9,375 pounds, respectively), amounting to 12,500 pounds, and acting as represented by the dot-dash horizontal line between P_1 and P_2; and the sum of the weights (W_1 and W_2) of the first two sections, amounting to 48,125 pounds, acting through their common center of gravity $G_{1\text{-}2}$. By producing these two forces to intersect, and finding where their resultant cuts the second bed joint, we determine a second point in the line of resistance. Similarly, the intersection of the resultant acting on that part of the dam above any bed joint with said bed joint can be found. By joining the consecutive points where the resultants cut their corresponding bed joint the line of resistance is determined.



RESISTANCE LINE OF DAM.

In the case of the Austin dam the line of resistance fell within the iddle third of the bed joints, and there was therefore no tension on ıy bed joint.

By using the force polygon shown on the right-hand side of Pl. V, ıe work of constructing the line of resistance can be greatly facili- ıted. Lay off consecutively, in a vertical line, W_1 (the weight of the rst section), W_2 (the weight of the second section), W_3 (the weight the third section), etc., and in a horizontal line lay off P_1 (the first ater pressure), P_2, P_3, etc. It is clear that the lines in this diagram ining the ends of W_1 and P_1, W_2 and P_2, W_3 and P_3, etc., are paral- l and equal in magnitude to the resultants acting on the first-second, ıe first-second-third, etc. All that is necessary to find the line of sistance is to produce P_1 to intersect a vertical through G_1, and ırough the point of intersection draw a line parallel to the first agonal in the force diagram, to cut the first bed joint, thus deter- ining the first point in the line of resistance. Again, produce the ne of horizontal pressure represented by the dot-dash line between ı and P_2 to cut a vertical through $G_{1\text{-}2}$, and through the point of ıtersection draw a line parallel to the second diagonal in the force iagram, to cut the second bed joint, thus determining the second ɔint in the line of resistance. In this way all of the points in the ne of resistance can be found.

If it is desired to use graphical methods to find the position of the ɜsultants of the pressures, select any convenient point as a pole and ɔin it to the ends of P_1, P_2, P_3, etc., as shown in the smaller diagram n the right-hand side of Pl. V; then construct the equilibrium olygon, as shown in the diagram to the right of the section of the am, as follows: First draw a line parallel to the line connecting the ole with the right-hand end of P_1; this line will cut P_1 at any ssumed point; then draw a line parallel to the second diagonal from ıe pole, and passing through the point of intersection of our first iagonal of the equilibrium polygon and P_1; this line will cut P_2; and ırough this point of intersection a third line of the equilibrium poly- on is drawn parallel to the third diagonal from the pole; this diago- al will cut P_3. In this way the complete equilibrium polygon is onstructed. The position of the resultants of P_1 and P_2 can be ɔund by producing the third diagonal of the equilibrium polygon ntil it meets the first diagonal; that of P_1, P_2, and P_3 can be found y producing the fourth diagonal until it meets the first diagonal in ıe equilibrium polygon; and so on. By drawing lines through these oints of intersection parallel to the resultant pressures on the ɜspective sections, we have the positions of the resultant pressures, s shown in the diagram (Pl. V) by the dot-dash horizontal lines. 'he first pressure in the case before us was not absolutely horizontal, n account of the rounded edge at the top on the upstream face, but ; was so nearly horizontal that it will not materially modify the final nalysis.

The best modern appliances were used in the construction of the dam. The granite material for the facing was obtained from Granite Mountain, near Marble Falls, being hauled from the quarry to the dam over the Austin and Northwestern Railway, a distance of 70 miles, and delivered at the east end of the dam, as shown in Pl. IV, *A*. The granite blocks were of average dimensions and weighed 4 tons each. The four classes of material used—i. e., the limestone rubble, the cement, the sand, and the granite—were transported from the end of the dam to place by a cable 2½ inches in diameter, stretched between two towers—one on the east and the other on the west bluff—1,350

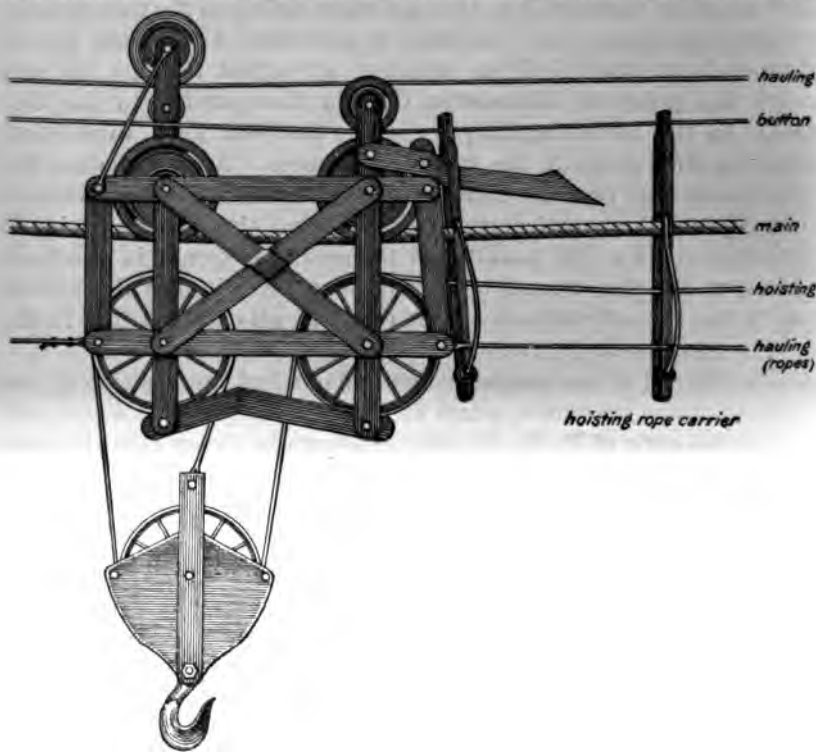


FIG. 4.—Saddle used on cable conveyer.

feet apart. The cable was anchored to "dead men" at the ends, weighted down by stone. The saddle shown in fig. 4 was specially designed for this work, and ran on the main cable. The wire ropes were known as the "hauling rope," the "hoisting rope," and the "button rope." The hauling rope was attached to the lower part of the frame work of the saddle, passed over pulleys at both towers, and wound around a drum under the east tower. The endless hauling rope was operated by an engine to which its drum was attached. It was completely under the control of the operator, and could be stopped in any position along its course. After being checked in the

A. POWER-HOUSE FOUNDATIONS AND OUTLET PIPES FROM TURBINES A FEW DAYS BEFORE FAILURE OF DAM

B. LIMESTONE STRATA AT HEAD GATE

position desired, the drum operating the hoisting rope was brought into motion and the load was lowered to the dam.

The granite blocks and the larger limestone rubble stones were handled by immense tong-like grips. The cement and sand were loaded into cages, transported to the place of construction, and there dumped on the dam. The cement mortar was made at the place where it was to be used, and the blocks of masonry were placed where needed by crane derricks shown in Pl. IV, *B*.

A wire rope one-half inch in diameter was used in connection with the cable and saddle to prevent excessive vibration of the operating ropes. On this rope there were buttons which increased in size from the tower to the west. The hoisting rope was supported at different points by carriers which rested, when the saddle was stationary, on the main cable. This carrier consisted essentially of two parallel bars, between which and near the lower end a small pulley was supported to carry the hoisting rope. A series of slots were arranged in the upper part of the carriers through which some of the buttons could pass. When near the east tower the saddle supported all of the carriers on a horn. In moving from the tower to the west, the smaller button passed through all of the carriers except the last, which it took off the horn; the second button passed through all of the remaining slots except that in the second carrier, which it pulled off the horn; etc. The carriers were thus stripped off the horn by the buttons and rested on the main cable, affording a groove or support for the hoisting rope and reducing its vibration.

LEAK UNDER HEAD GATE.

On May 30, 1893, the water from the lake cut under the east bulkhead and undermined the proposed foundation of the power house. It entered a seam in the limestone slightly above the point indicated at B in fig. 5, about 90 feet from the dam. From this point the course of the water was at an angle of about 30 degrees to the axis of the river to the left, and it also took a downward course and passed about 25 feet under the foundation of the head-gate masonry. A view of the power-house foundation a few days before the break is given in Pl. VI, *A*. The water issued from the west wall of the proposed power-house foundation and soon wrecked it. The general course of the water was from a point near the east end of the head-gate masonry diagonally across the foundation to the point of exit.

A cofferdam about 125 feet long was constructed of framework, with dirt and hay as fillers, from a point on the shore above the entrance to the crevice to a point near the end of the dam. This effectually cut off the water from the proposed forebay, and the work of repair commenced. As originally designed, the head-gate masonry contemplated 9 large pipes, but only 7 were put in.

The head-gate masonry cracked about 40 feet from the end of the

dam, along the line HM in fig. 5, and settled. The earth east of the east end of the head gate settled for a distance of 25 feet. Plans were immediately adopted for raising and strengthening the cofferdam so as to provide against floods, for rebuilding the head gate, and for the construction of a power-house foundation. The broken part of the head-gate masonry was removed (leaving only that over penstocks 1

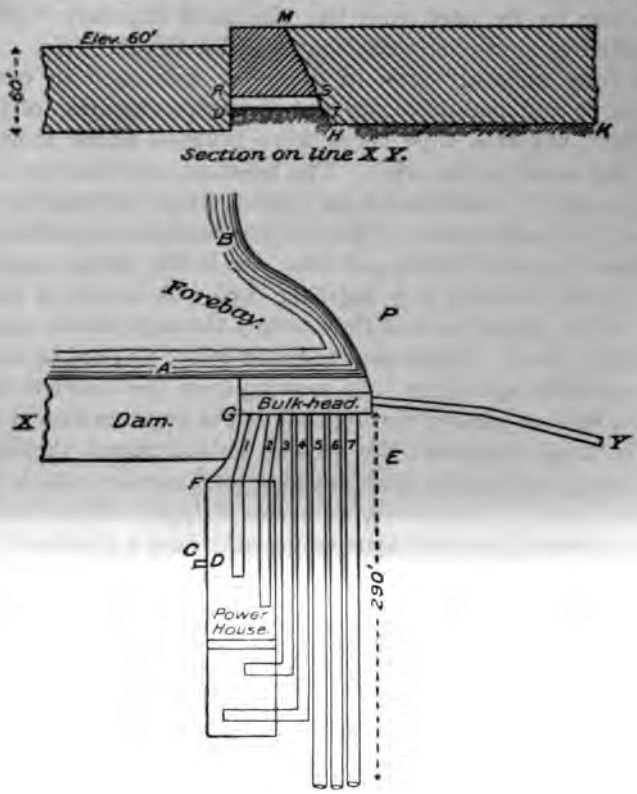


FIG. 5.—Section and sketch plan of bulkhead, showing location of power house and penstocks. HK is bottom layer of concrete filling resting on hard limestone strata; HM is line of crack; RS is the original level of bulkhead masonry; RSTU is tunnel (6 feet by 6 feet by 60 feet long) filled with concrete; A is point where drift indicated leak in the spring of 1899; B is location of leak discovered in the fall of 1899; P is point from which view shown in Pl. VII, *B*, was taken; FG is wing wall; C is 10-inch horizontal pipe projecting from wall of power house, known as "the spring;" D is cement chamber for controlling water and directing it through C; 1 to 7 are penstocks; E is the point at which the leak in penstock was found in February, 1900.

and 2), and an excavation nearly 200 feet long and 70 feet deep, with an average width of 7 feet, was made. This trench reached to a level of 57 feet below the crest of the dam, or within 3 feet of the level of the toe. The head-gate masonry was rebuilt, provision being made for only seven 9-foot penstocks, the rest of the excavation being filled by a concrete wall 112 feet long, which was 8 feet thick for the 90

A. DISCHARGE OF LAKE THROUGH DAM, OR THE SO-CALLED "SPRING."

B. VIEW SHOWING TWO METHODS EMPLOYED TO STOP LEAK THROUGH DAM.

eet next to the head gate and only 5 feet thick for the rest of the distance. In excavating for this extension wall, alternate layers of hard nd soft limestone were encountered, as shown in Pl. VI, *B*. The ottom layer of the concrete filling (HK, fig. 5) was laid on one of hese hard strata, but it was fully demonstrated that a current of vater was running underneath. Several holes were drilled, through vhich the water welled up in jets several inches high. However, it vas thought safe to plug these holes and to ignore the stream below. The bulkhead masonry originally extended to the level RS, fig. 5, 6 feet below the top of the dam; but as an extra precaution a unnel (RSTU) 6 feet by 6 feet square and 60 feet long was cut under he bulkhead masonry back to the end of the dam proper, and the pace was filled with concrete. The space below the 42-foot level inder the tunnel was not disturbed.

The foundation for the power house was then excavated to a depth of more than 80 feet below the crest of the dam. The original contractors, after a dispute in regard to the excess of water flooding heir work, surrendered their contract. The new contractors succeeded in controlling this water by the use of a cement chamber at D, fig. 5, and a 10-inch horizontal pipe, which projects from the wall of the power house at the point C, about 54 feet below the crest of the dam. This is often referred to as "the spring." A view of it is shown in Pl. VII, *A*, where it is being discharged through a 10-inch pipe in the third course of granite above the toe of the dam. Measurements taken in October, 1895, showed a range, on the horizontal surface of water in the tailrace, of 5.1 feet and a fall of 5.8 feet, giving a discharge of 4.6 feet per second. A 3,000,000-gallon pump entirely exhausted this "spring." In May, 1897, the flow from the so-called "spring" suddenly increased. An average of several measurements gave a range of 11 feet and a fall of 5.8 feet, and therefore a discharge of about 10 second-feet. Measurements recently taken give a range of 8.8 feet and a fall of 5.8 feet, and therefore a discharge of 8 second-feet.

In the spring of 1899 it was discovered, from the behavior of drift, that water was disappearing from the lake at point A, fig. 5. This source of leakage was stopped by filling the lake at that point with clay, loose and in bags. While the filling in was going on the discharge of water from the 10-inch pipe almost ceased for a few hours, but soon reached its normal amount. The filling kept the water discolored and muddy.

In the fall of 1899 it was noticed that water was disappearing at point B, fig. 5, only a few feet from the shore. A cofferdam of sheet piling was constructed around this point and it was filled with hay and earth. A view, taken from point P, fig. 5, of the two leaks and of the method of filling by clay and sheet piling is shown in Pl. VII, *B*. The clay filling is the pile of dirt adjoining the upstream face of the dam.

In the latter part of December, 1899, the earth in front of and between the power house and bulkhead, and at point E, fig. 5, began to sink and continued to sink until it was determined to remove the earth covering the 9-foot penstocks under the sunken areas, in order to discover the cause. The removal of the earth showed that penstock No. 3 (fig. 5) was buckled, and that at one place it had sunk about 20 inches. A bold stream of water—at least 2 second-feet in amount and 16 feet below the top of the dam—was found when the earth was taken out between the power house and penstock No. 3, and between penstocks Nos. 3 and 4. The stream of water was partly deflected around the north end of the power house and under penstocks Nos. 1 and 2. The water did not rise in the excavation, and it was discharged through some 2-inch pipes at F, fig. 5, 14 feet below the crest of the dam, through two or three other small pipes, and by absorption through the wing wall FC and through the east wall of the power house. Penstock No. 5 was also found buckled at a joint about 35 feet from the bulkhead. The water which caused the settling came from a broken 2-inch pipe tapped into the bottom of penstock No. 5. The break was at an elbow just below the penstock, at a point about 16 feet below the crest of the dam and 40 feet from the south side of the bulkhead masonry.

FLOW OF COLORADO RIVER.

The minimum flow of Colorado River was estimated in 1890 to be 1,000 cubic feet per second; and it was upon this estimate that the engineers based their calculations of the power that would become available by the erection of a dam 60 feet high above low water. With an effective head of 57.5 feet and a machinery efficiency of 80 per cent of the theoretic, for this flow there would be available continuously 5,227 horsepower, and if held back nights and Sundays and used only 60 hours a week, 14,600 horsepower.

After February 10, 1897, the city's plant furnished power for its own water and light system, for the Dam and Suburban Railway, for the Rapid Transit Street Railway, and for various motors in the city. This required, in the opinion of the superintendent of water and lights, an average of about 1,000 horsepower; that is, with a machinery efficiency of 75 per cent, about 200 cubic feet of water per second. During 1897 the lake level was below the crest of the dam eighty-nine days, showing that the supply of water at the forebay was not sufficient to carry the load upon it. In 1898 the water was below the crest one hundred and eighty-six days, and in 1899 it was below two hundred and four days, making a total of four hundred and seventy-seven days during the last three years, or 43 per cent of the time from January 1, 1897, to January 1, 1900.

The maximum flood height occurred on June 7, 1899, when the water level of the lake was 9.8 feet above the crest of the dam, giving

A. MARBLE FALLS ABOVE LAKE McDONALD

B. VIEW OF RIVER FROM MOUNT BONNEL AFTER DESTRUCTION OF DAM.

flood discharge of 101,000 cubic feet per second, or enough water assing each second to run the plant eleven days.

From March 15 to April 17, 1899, the lake level was more than 10 eet below the crest of the dam; and again, from September 16 to ctober 23, it averaged about 10¼ feet below the crest. In all, it was ore than 10 feet below the crest of the dam during seventy-two ays in 1899, or about one-fifth of the year. During these periods of w lake level the following measurements of the flow were taken:

Discharge measurements of Colorado River during low lake level.

Date.	Locality.	Gage height.	Discharge.
1899.		*Feet.*	*Second-feet.*
January 31	Head of lake	—7.60	210
March 13	Marble Falls	—9.85	197
March 15	Forebay at dam	—10.00	206
Do	Tailrace at dam	—10.00	233
Do	Forebay at dam	—10.05	186
March 17	Tailrace at dam	—10.05	203
Do	Between bridges	—10.05	267
October 3	Head of lake	—10.45	134
October 4	do	—10.35	134
October 6	Marble Falls	—10.25	105
October 4	Head of lake	—10.35	136

In explanation of these measurements it is necessary to say that the ow level of the lake compelled the authorities of the city to cut off the ower from the Rapid Transit and the Dam and Suburban railways n March 20 and September 9, and from the tower lights on January 2 and September 6. The flow (206 and 186 second-feet) into the enstocks was then being utilized for pumping water, for operating he street-car systems, and for running a few motors in the city. The ffective head on the turbines was about 50 feet, giving a theoretic orsepower of 850. The actual horsepower was about the same. The low below the dam, at the tailrace, was in excess of the inflow by 27 nd 16 second-feet, respectively. The flow through "the spring" ipe was 10 second-feet, and the rest can be accounted for by the nomentary fluctuations in the supply to the turbines that ran the treet-car systems. This fluctuation was caused and controlled by he demand made by the motors and the cars for power. The inflow as controlled by automatic gates that responded to these demands.

The difference between the inflow and the flow at the station between he bridges was 81 second-feet. Barton Springs supplied 20 second-eet of this, the power-house "spring" 10 second-feet, and other mall springs along the river between the dam and the railroad ridges supplied a large part of the remainder.

While the city plant was furnishing power for all of the purposes nentioned, the average flow at the tailrace was about 300 second-feet,

which should have developed 1,500 horsepower. During the day the flow was less than during the active hours of the night, but measurements taken on the tailrace gave a flow of 295 second-feet, with the turbines which ran the city's pumps, the street-car systems, and the city motors in full operation.

All measurements at the station between the railway and the highway bridges were so completely controlled by the flow through the penstocks at the dam that they gave no indication of the unrestricted flow of the Colorado.

The minimum flow was not sufficient to carry the load of the pumps, the lights, two street-car systems, and the motors for power plants in the city, and when this flow was decreased by the evaporation from the lake surface (3 square miles) the lake level sank rapidly.

The low stages of the water in 1899 can not be ascribed to a decreased annual rainfall but to a very irregular one. For the purpose of comparison, the rainfall at Austin since 1856, with the exception of the years 1882, 1883, and 1884, records for which are not obtainable, is given below.

Rainfall at Austin, Texas.

Year.	Rainfall.	Year.	Rainfall.	Year.	Rainfall.
	Inches.		*Inches.*		*Inches.*
1856	19.6	1870	42.5	1887	23.5
1857	33.0	1871	30.1	1888	51.8
1858	36.4	1872	33.3	1889	43.2
1859	28.2	1873	43.4	1890	36.4
1860	29.6	1874	46.5	1891	37.1
1861	28.7	1875	29.3	1892	34.7
1862	22.2	1876	32.6	1893	16.3
1863	34.7	1877	41.8	1894	27.5
1864	25.2	1878	21.6	1895	31.9
1865	37.8	1879	18.3	1896	21.9
1866	40.5	1880	48.1	1897	28.1
1867	27.3	1881	25.3	1898	25.9
1868	40.1	1885	40.3	1899	28.0
1869	38.5	1886	32.4		

The rainfall of 1899 (28 inches) was greater than that of 1898, nearly equal to that of 1897, and greater than that of 1896; but the rainfall of that year (1899) was concentrated and not distributed like that of previous years. In 1899 very heavy rains fell in the months of April and June. In the latter month occurred the highest flood within the last twelve years.

In the discussion that arose over the proposition to change the cross section of the dam, as shown in fig. 3, the question of the amount of flow and its effect on the toe of the dam was considered. Mr. Frizell then brought to the attention of the engineering public the following proof of the formula of flow: Let H = the height of lake level above crest of dam; x = the part of this height that gives the velocity over the crest; Q = flow in second-feet; v = velocity in feet per second;

A. VIEW OF DAM FIVE MINUTES BEFORE FAILURE ON APRIL 7, 1900.

FLOOD POURING OVER DAM ON JUNE 7, 1899. LAKE LEVEL 9.25 FEET ABOVE CREST OF DAM

= length of crest; $H - x$ = depth of water on crest: Then $v = \sqrt{2gx}$ where $2g = 64.32$ feet; $\therefore Q = v(H - x)\, l = l(H - x)\sqrt{2gx}$. his must be a maximum, hence the derivative of Q with respect to must be zero; hence—

$$Q = l\sqrt{2g}\left[\frac{H - x}{2x^{\frac{1}{2}}} - x^{\frac{1}{2}}\right], \therefore x = \tfrac{1}{3} H, \therefore Q = 3.09\, l\, H^{\frac{3}{2}}.$$

the case of the Austin dam, $l = 1091$, $\therefore Q = 3362\, H^{\frac{3}{2}}$.

The formula generally used to find the flow over crests is $Q = cl\, H^{\frac{3}{2}}$. ith a view to testing the reliability of this formula and finding e coefficint c, in January and March, 1900, measurements of velocity ere taken, with a small Price electric meter, by Mr. E. E. Howard, a nior in the engineering department of the University of Texas. The m broke before the investigations were completed, but the following lues of the coefficient c were found:

Tabular statement of values of coefficient c.

Date.	H.	h. (a)	v.	c.
1900.				
January 15	1.09	0.92	3.85	3.09
Do	1.09	.92	3.99	3.21
Do	1.09	.92	3.85	3.09
Do	1.09	.79	4.22	3.14
January 18	.72	.625	2.33	3.06
Do	.72	.625	2.33	3.06
Do	.72	.625	2.37	3.11
Do	.72	.625	2.29	3.00
Do	.72	.625	2.33	3.06
Do	.72	.625	2.33	3.06
Do	.72	.626	2.33	3.06
Do	.72	.625	2.29	3.00
Do	.72	.625	2.37	3.11
Do	.72	.625	2.29	3.00
Do	.72	.625	2.33	3.06
January 26	.42	.33	1.57	3.06
Do	.42	.33	1.61	3.13
Do	.42	.33	1.61	3.13
Do	.42	.33	1.61	3.13
March 28	1.44	1.04	4.95	3.32
Do	1.44	1.04	4.95	3.32
Do	1.44	1.04	5.01	3.36
Do	1.32	.96	5.27	3.33
Do	1.32	.96	5.18	3.26
Do	1.32	.96	5.27	3.33
Do	1.32	.96	5.18	3.26
Do	1.32	.96	5.27	3.33

a Depth of water on crest.

Floods of historic importance occurred as follows:

	Feet.
February, 1843	36
March, 1852	36
July, 1869	43
October, 1870	36
June, 1899	23
April, 1900	33

On July 3, 1869, began the longest and most uninterrupted rain ever known in Austin. It rained without stopping for about sixty-four hours, and the river rose to a height of 45 feet. The lower part of the city was overflowed and several people were drowned. The town of Webberville, 16 miles below Austin, was also overflowed, and Bastrop, 30 miles below, was inundated.

ECONOMIC ASPECT.

The population and taxable wealth of the city at various times is shown in the following table:

Population and taxable wealth of Austin, Texas.

Year.	Assessed valuation of real estate.	Assessed valuation of personal property.	Total assessed value.	Increase each year.
1889	$5,665,886	$2,324,757	$7,990,643	.....
1890	6,462,209	2,473,343	8,935,552	$944,909
1891	7,577,116	2,936,962	10,514,188	1,578,530
1892	8,054,405	2,719,318	10,773,723	259,635
1893	8,184,297	2,697,633	10,881,930	108,207
1894	8,384,429	2,640,342	11,025,368	144,335
1895	8,520,659	2,863,075	11,384,734	259,366

Before the issuance of the $1,400,000 of water and light bonds in 1890, the bonded indebtedness was as follows:

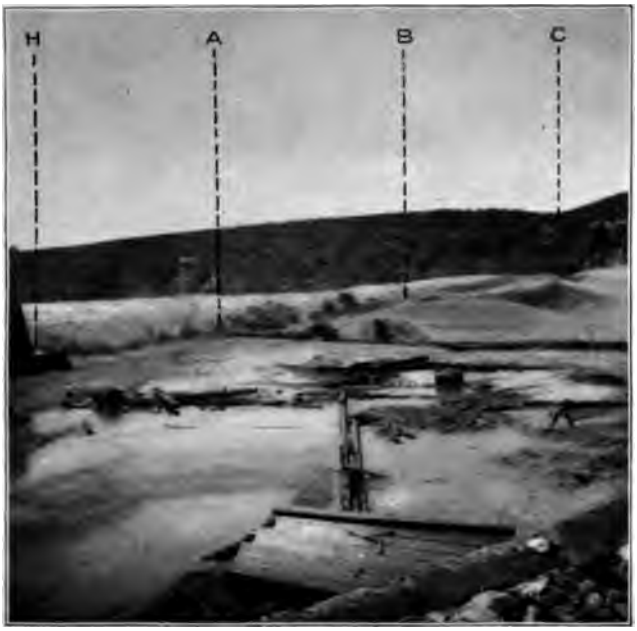
Six per cent bonds due in 1901	$12,500
Six per cent bonds due in 1905	40,000
Six per cent bonds due in 1925	72,500
Total	125,000

On May 5, 1890, the city authorized the issuance of $1,400,000 water and light bonds at 5 per cent. The first $400,000 were sold on October 15, 1890, to a syndicate of local capitalists at par and accrued interest. In April, 1892, the Union Trust Company bought $500,000 of the bonds at 95 cents on the dollar, and in 1893 Bernard Corrigan bought $62,000 of them at 95. Later, in 1893, $388,000 were sold at 92 and $50,000 at par.

Total receipts from bonds.

450 bonds, at par	$450,000
562 bonds, at 95	533,900
388 bonds, at 92	356,960
Total	1,340,860

The break in the head-gate masonry and the destruction of the first foundation of the power house caused an outlay of $97,000 above all expectations, and it was apparent that another issue of bonds would be necessary to complete the enterprise as originally contemplated



A. VIEW THREE MINUTES AFTER FAILURE OF DAM.

A—B and B—C are portions of dam first broken, H—A is eastern part of dam (83 feet long on crest) left standing.

B. VIEW TEN MINUTES AFTER FAILURE OF DAM.

D′—B′ is broken portion of dam still standing; B′—C′ is western portion of break; C is end of western part of dam (456 feet long on crest) left standing.

Under the direction of the board of public works the following penditures were made:

Disbursements.

Engineering expenses	$58,402.37
Dam	611,313.39
Electric-light dynamos	7,700.55
Electric-power generators	6,708.50
Belting	43.81
Power house	45,917.98
Penstocks, head-gate castings, etc	47,792.19
Draft-tube excavations	2,314.08
Pump foundations	658.66
Bonds	1,237.50
Head gates	2,122.60
Sluice pipes	2,420.19
Repairs on account of break	96,941.23
Wheels, pumps, etc	43,418.02
Countershafting, pulleys, etc	1,203.85
Water distribution system	158,081.04
Electrical distribution system	115,678.29
Railroad	87,431.90
Office expenses	10,170.03
Submerged lands	27,732.15
Head-gate masonries	46,934.17
Power-house foundations	11,527.60
Miscellaneous	5,375.74
Total	1,391,129.64

The board of public works was discontinued on the completion of dam in 1893, and the city council then assumed control and naged the plant until the water and light commission was created charter in 1897. At the time the board of public works was abol-ed there was due and unpaid on contracts the sum of $55,896.87. e water and light commission had exclusive supervision, manage-nt, and control of the waterworks system, the electric lights, the wer plant, and all property, funds, and business belonging or per-ning thereto.

The $200,000 of bonds issued in 1895 were utilized in paying the ,000 indebtedness left by the board of public works, and in com-ting the water and light system, with the exception of the reservoir. e reservoir was never built. After a site had been practically osen it became evident that it would be necessary to filter the water the lake, and upon the advice of Mr. Allen Hazen, of New York y, the sanitary engineer called in for consultation, it was deter-ned to construct filtering galleries in the sand flats about 2 miles low the dam, and to transfer the pumps to a new pump house to be ected near the filters. These galleries, three in number, were in ccessful operation when the dam broke. The lower station was

equipped with a 6,000,000-gallon pump and a 300-kilowatt synchronous motor, which cost $29,380. The filtering galleries and connections cost, in round numbers, $21,000.

No better idea can be given of the operation of the plant than to append a report for the twelve months ending November 30, 1899:

Earnings:	
Water	$40,369.39
Light	30,192.61
Power	12,777.14
Miscellaneous	1,206.86
Total	84,546.00
Collected in cash	67,298.12
Due by city	12,745.19
Garnisheed accounts	2,836.70
Due on bills, etc	1,665.99
Total	84,546.00

For the purpose of comparison, the receipts and expenditures for the last three years are here tabulated:

Receipts and disbursements of power plant at Austin, Texas.

Year ending—	Receipts.	Operating expenses.	Extensions.	Total disbursements.
November 30, 1897	$82,059.44	$36,709.07	$57,821.02	$94,530.09
November 30, 1898	93,651.05	36,239.32	38,724.54	74,963.86
November 30, 1899	82,927.43	39,742.31	34,711.95	74,454.26

SILTING UP OF LAKE McDONALD.

In 1890 cross sections of Colorado River were taken at sixteen stations, as shown in the tabular statement on page 38 and in fig. 6. The complete outline of the diagrams in fig. 6 represents the original cross section, the horizontal line being the water surface even with the crest of the dam and the shaded area showing the amount of silt that had been deposited up to February, 1900. All vertical dimensions are exaggerated three times over the horizontal dimensions. Cross sections were again taken for the United States Geological Survey in May, 1897, also in January, 1900. The silt deposited from 1893 to 1897 is represented by the lower shaded area, and that deposited from 1897 to 1900 by the upper shaded area.

The water first flowed over the crest of the dam on May 16, 1893, at which time there were 83,556,000 cubic yards of water in the main channel of the lake up to the level of the crest of the dam; in 1897 there were only 51,889,000 cubic yards of water in the channel, the remaining 31,667,000 cubic yards (or 38 per cent of the original capac-

A. VIEW ABOUT TWO HOURS AFTER BREAK

B. VIEW ONE HOUR AFTER BREAK.

ity) being silt. Estimated in depths on a square-mile base we have, in 1893, a volume of water equal to a depth of 80.9 feet, and in 1897,

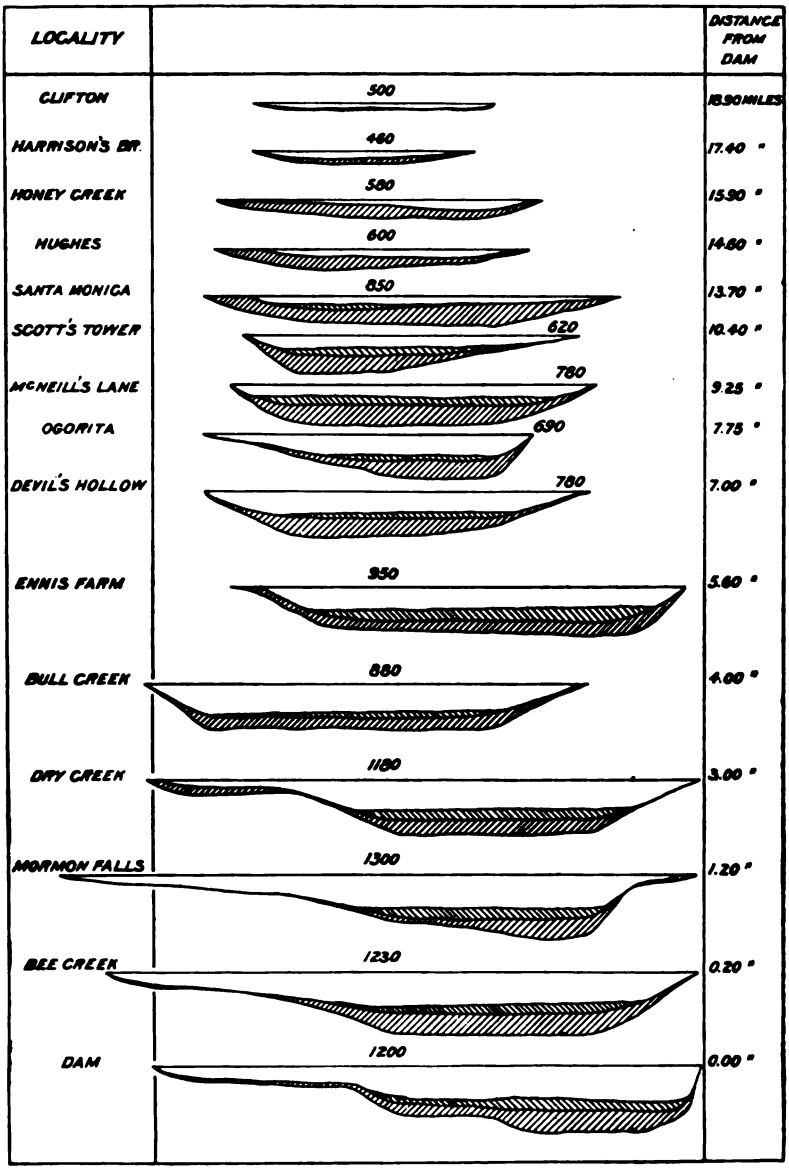


FIG. 6.—Cross sections of Lake McDonald, illustrating accumulation of sediment between 1893 and 1897 (illustrated by the lower shaded area) and between 1897 and 1900 (illustrated by the upper shaded area). The number above each section indicates its length, in feet.

four years later, we have a volume of water equal to a depth of 50 feet and silt to a depth of 30.9 feet, showing the average amount of silt deposited annually to be 7.7 feet, on a square-mile base.

The following table shows the maximum and mean depths of water for 1893 and 1900, the maximum and mean depths of silt for 1900, and the percentage of silting up at the respective stations:

Table showing silting up of Lake McDonald.

Station.	Maximum depth of water.		Maximum depth of silt, 1900.	Mean depth of water.		Mean depth of silt, 1900.	Amount of silting up to February, 1900.
	1893.	1900.		1893.	1900.		
Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Per cent.*
0.0	66.0	39.0	27.0	40.1	27.5	12.6	31.2
0.2	67.0	38.0	27.7	37.6	26.5	11.1	32.2
1.2	63.8	35.5	28.3	30.6	21.7	8.9	30.2
3.0	56.0	31.5	24.5	33.4	21.5	11.9	38.8
4.0	47.8	31.5	19.0	38.0	23.5	14.5	37.9
5.6	47.5	27.5	23.0	36.7	23.0	13.7	42.0
7.0	47.0	22.0	26.0	36.3	17.4	18.9	56.3
7.75	44.8	20.5	25.0	30.7	15.4	15.3	56.3
9.25	40.4	13.4	29.0	30.8	10.2	20.6	66.9
10.4	40.9	13.5	27.4	27.2	7.9	19.3	71.8
13.7	29.4	9.8	26.0	20.3	5.5	14.8	78.9
14.6	24.0	12.5	16.0	17.2	9.0	8.2	50.4
15.9	16.6	12.0	15.0	13.2	10.0	3.2	60.0
17.4	13.2	9.5	7.0	11.2	8.8	2.4	30.0
18.9	7.6	5.0	2.6	5.6	3.9	1.7	33.0
20.0	3.7	2.2	1.5	2.8	2.0	1.8	35.0

The maximum depth of silt is not always equal to the difference between the maximum depth of water for 1893 and 1900, as the channel shifted at several points. This is very noticeable at station 13.7, known as the Santa Monica (or Sulphur) Springs station. The last column ("Amount of silting up," etc.) gives the ratio that the present cross section of silt bears to the original cross section of water. Thus at Santa Monica Springs (station 13.7) 78.9 per cent of the original cross section has filled with silt.

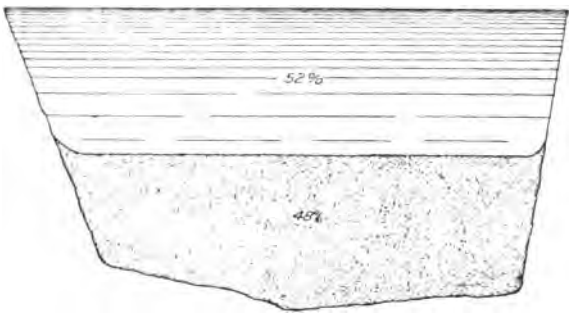


FIG. 7.—Generalized cross section of Lake McDonald, showing accumulation of sediment.

In February, 1900, there were 43,460,000 cubic yards of water in the main channel of the lake beneath the level of the top of the dam (equivalent to 42.1 feet on a square-mile base) and 38.8 feet of silt. Thus 48 per cent of the original storage capacity of the lake was at that time mud. Up to that date the average rate of deposit, on a square-mile base, was 5.8 feet per year.

A. VIEW ABOUT 350 FEET BELOW DAM, SHOWING WAVES THOUGHT TO BE DUE TO SECONDARY DAM FORMED BY DÉBRIS FROM WRECK.

B. POWER HOUSE OF AUSTIN WATER, LIGHT AND POWER COMPANY ABOUT 2 MILES BELOW DAM.

[redacted]

In 1897 this silt, to within 2 miles of the head of the lake, was a fine, impalpable, absolutely gritless deposit, and where newly exposed would not bear an appreciable weight on its surface. The writer has often tried its resistance all along the lake, and an oar could be driven into it several feet with moderate pressure. Shovelfuls of it placed upon boards in a heaped-up mass would immediately settle and spread so that the upper surface was almost horizontal. A barrelful of it, when first taken up at Santa Monica Springs, soon spread out in a flat sheet. At the head and for about 2 miles down the lake the silt consisted of a sand which readily deposited when the velocity of the stream was checked by the waters of the lake. At occasional points below the head of the lake small bars of sand were found near the mouths of small canyons or creeks.

From March 15 to April, 1899, the water level of the lake was a

FIG. 8.—Layer of silt remaining on plateau after destruction of dam.

little more than 10 feet below the crest of the dam. The water again commenced flowing over the crest of the dam on April 21 and continued to flow over, at small depths, until June 7, when the river rose to a height of 9.8 feet above the crest of the dam. This flood continued until June 12, and its effect on the cross sections near the head of the lake was marked. The sections at stations 14.6, 15.9, 17.4, and 18.9 were scoured out 2 to 3 feet deeper than the sections of 1897, and at station 15.9 a sand bar was deposited on the inside (left) of the curve of the river, contracting the channel to less than half its former width.

The typical section illustrating the ratio of silt and water areas for the whole lake is about midway between stations 5.6 and 7.0, i. e., about one-fourth of a mile below the Chautauqua wharf. Fig. 7 illustrates this section, the vertical scale being magnified ten times.

Fig. 2 shows the configuration and geography of the lake formed by

the dam. The river, as shown by fig. 1, for 200 or 300 miles, flows through a hilly country, from above Colorado City, on the Texas and Pacific Railroad, and in its course absorbs the waters of the Concho, the San Saba, the Llano, and the Pecan Bayou. All of the country drained by these tributaries is hilly, with the exception of a few miles along the head of the Colorado and the Concho.

When the break occurred the silt in the immediate vicinity of the dam would have flowed out had there been no water. Just above the part of the dam that gave way was a plateau whose surface was on an average about 18 feet below the crest of the dam. At the time of the break the lake level was 11 feet above the crest of the dam, making the depth of water on the plateau 29 feet. The torrent poured over this plateau with immense velocity, as shown in Pls. X and XI. The silt on the plateau was cut away with such swiftness that in three hours it was swept almost clean. Only a slight amount remained, as can be seen from fig. 8; the men are standing on the original soil of the plateau, the silt appearing behind them.

In the main channel the upper surface of the silt was 38 feet below the crest of the dam, giving, at the time of the break, a depth of water in the main channel of 49 feet. After the water level dropped below the plateau the current was confined to a narrow gorge. The flood continued in the main channel for several days. A week after the failure the silt along the shores of the former lake was cut into fantastic shapes by the currents of the river and those of many mountain gorges. The silt in contact with the dam undoubtedly increased the pressure against it, but that portion of the dam across the main channel where the silt was 28 feet deep and where the pressure was greatest was on a good hard rock foundation and successfully resisted it. There was practically no waterlogged drift in this silt; the soundings indicated mud bottom. The silt deposit kept the river at Austin muddy for months after the failure. (It is still muddy—November 1, 1900.)

Pl. VIII, *B*, is a view of the lake from Mount Bonnel, looking up the river, two weeks after the break, with the freshet still on. The extreme right-hand part of the curve is the mouth of Bull Creek.

For purposes of comparison, the silting up of reservoirs is best reduced to heights and depths on a square-mile base. To derive an expression for the amount of silt deposited in a given time, let x equal depth, in feet, of silt deposited in a year by each foot of water in the reservoir, and let h equal the original depth of the reservoir. The depths of water are at the end of one, two, three, etc. n years:

First year, $h - h\,x = h\,(1 - x)$;
Second year, $h\,(1 - x) - h\,(1 - x)\,x = h\,(1 - x)^2$;
Third year, $h\,(1 - x)^2 - h\,(1 - x)^2\,x = h\,(1 - x)^3$;
Fourth year, $h\,(1 - x)^3 - h\,(1 - x)^3\,x = h\,(1 - x)^4$.

Hence, if we let d = depth of water in n years, we have $d = h\,(1 - x)^n$.

In 1897 $h = 81$, $d = 50$, $n = 4$; $\therefore x = 0.1135$.

In 1900 we have $d = 0.52h$, $n = 6\frac{1}{3}$, $(1 - x)^{\frac{20}{3}} = 0.52$; $\therefore x = 0.09343$.

A. VIEW UPSTREAM ONE DAY AFTER FAILURE OF DAM.

B. VIEW WESTERLY ALONG LINE OF DAM ONE DAY AFTER FAILURE.

For safety let us assume the least value of x; the following table gives the results for each year on that assumption:

Table showing silting up of reservoirs.

n years.	Amount of water, $d+h$.	n years.	Amount of water, $d+h$.
1	0.907	12	0.308
2	.822	13	.279
3	.745	14	.253
4	.676	15	.230
5	.612	16	.208
6	.555	17	.189
6½	.520	18	.171
7	.503	19	.155
8	.456	20	.191
9	.414	25	.086
10	.375	30	.053
11	.340	40	.020

These results will not be correct for any reservoir in which there is an appreciable current acting on the bottom of the basin, i. e., on the upper surface of the silt. In Lake McDonald the level of the water could sink to 10 feet below the crest of the dam and there would still be a fair current in the penstocks, as the bottom of the forebay was 12 feet below the crest. When this condition obtained, as it did during the months of March, April, and October, 1899, there was a current on the upper third of the lake. Unless the lake was drained by the three 3-foot pipes at the west end of the dam (which did not occur after 1893), it was not possible for the current under ordinary conditions to affect the silt in the lower two-thirds of the lake. The results of the table are illustrated in fig. 9.

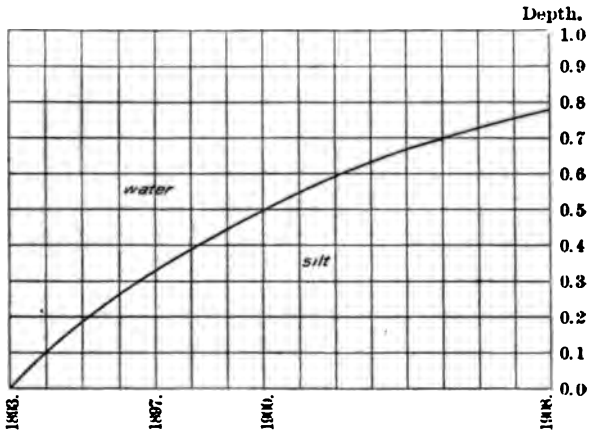


FIG. 9.—Curve illustrating progress of silting in Lake McDonald.

FAILURE OF THE DAM.

At Austin the Colorado emerges from a mountainous country which extends for a distance of over 200 miles in a northwesterly direction. The channel above Austin is for the most part a sinuous gorge held in by limestone mountains and hills. Austin is at the foot of a long range of mountains, 37,000 square miles of which afford a drainage area for Colorado River. The river is fed by the Perdinales, the

Llano, the San Saba, the Concho, and the Pecan Bayou. The configuration of the country is such that the water runs off rapidly into streams.

From 1 p. m. on April 6 to 4 a. m. on April 7 there was a rainfall of 5 inches at and in the vicinity of Austin, in a mountainous country and on ground already wet. In addition to this, tremendous rains fell all along the Colorado and its tributaries from Austin as far up as Llano, a distance of over 100 miles. The river rose rapidly, and by 10 a. m. on Saturday, April 7, it was apparent that the dam would be called upon to withstand the biggest flood since water first wetted its crest on May 16, 1893. At that hour the water level of the lake was more than 10 feet above the crest of the dam and it was rising nearly 2 feet an hour. The greatest previous flood height occurred at 9 p. m. on June 7, 1899, when the lake level was 9.8 feet above the crest of the dam. The water rose rather gradually throughout the day to its maximum level of 9.8 feet. Pl. IX, *B*, gives a view of the flood of June 7, 1899, taken when the lake level was 9.25 feet above the crest of the dam and the water level only 22 inches lower than that of April 7, 1900; and Pl. IX, *A*, is a reproduction of a snapshot picture taken with a small kodak five minutes before the dam broke. It shows conclusively that there was no drift in concentrated masses. Isolated logs and débris were passing, but they never came within 8 feet of the crest of the dam.

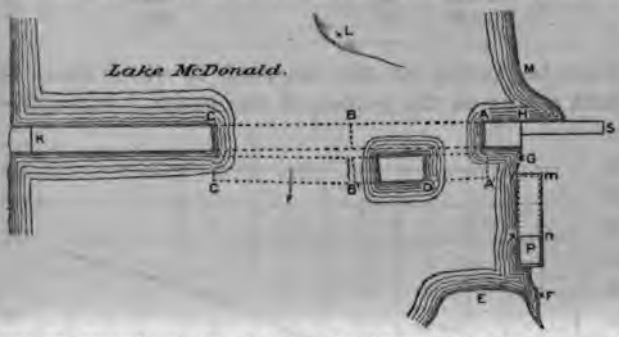


FIG. 10.—Plan showing break in dam April 7, 1900. KC is western part of dam (456 feet long on crest) left standing; HA is eastern part (83 feet long on crest) left standing; AB and BC are portions of dam first broken; xymn is dynamo room at power house; P is pump room; L is point from which view shown in Pl. XV, *A*, was taken; F is point from which view shown in Pl. XIII, *A*, was taken; G is point from which view shown in Pl. XIII, *B*, was taken; M is point from which view shown in Pl. XI, *A*, was taken; E is point from which view shown in Pl. IX, *A*, was taken; HS is bulkhead; B'C' and D'A' are portions of dam that broke and disappeared 45 minutes after break; B'D' is the broken portion of dam still standing; S is point from which view shown in Pl. XI, *B*, was taken.

At 11.20 a. m. on April 7, when the lake level had reached a height of 11.07 feet above the crest of the dam, the dam gave way at the point marked B in fig. 10, about 300 feet from the east end of the dam. Observers at E, F, and H all agree in their testimony that it first opened at B, and as though the mad current had simply pushed its way through the structure. Sooner than it takes to write these words the two sections AB and BC, each about 250 feet long, were shoved or pushed into the lower positions A'B' and B'C', about 60 feet from

A. VIEW OF POWER HOUSE ABOUT TWO HOURS AFTER FAILURE OF DAM.

B. WRECK OF POWER HOUSE.

heir former positions in the dam. There was not the slightest over-urning. After the warning break at B, the water over the part ABC vas seen to rise several feet, and the next instant the pent-up waters vere pouring over the sections A'B' and C'B'.

The view shown in Pl. X, *A*, was taken at 11.23 a. m., or three ninutes after the failure. The parts may be identified by comparing Pl. X, *A*, with fig. 5 and with the sketch plan, fig. 10, the view shown n Pl. X, *A*, extending slightly beyond C in fig. 10. By 11.30 a. m. the ake level had fallen to the crest of the dam, and the sections A'B' and B'C' were seen to be upright, each still a solid mass, complete, unbroken, and intact, except for the scaling off of the granite facing from the lownstream side, occupying a position practically parallel to the dam, a view of which is shown in Pl. X, *B*, a snapshot taken ten minutes after the break. To the casual observer the detached portions at this ime had the appearance of having been erected in their new positions by the original contractor. The crests of the sections A'B' and B'C' vere about on a level with their original positions, except at C, where he crest was slightly higher, giving B'C' a slight longitudinal dip oward the power house. Measuring along the crest the break left 56 feet of the dam (KC in fig. 10), at the west end and 83 feet (AH) at the east end still standing unaffected.

As soon as the sections were broken out and moved to the positions A'B' and B'C', the partially pent-up waters rushed through the gap, hose held back by CK producing a strong current in the direction of he power house. This current struck the wall of the power house almost on a level with the floor of the pump room (about 12 feet below he crest of the dam), crushed in all of the windows on the west side, looded all of the lower stories, and caught and drowned five em-ployees and three small boys. Two of the employees miraculously scaped by climbing through a belt hole in the dynamo room (x y m n, ig. 10). These workmen were pumping water from the lower portions of the power house.

At 12 o'clock, forty minutes after the break, the broken section B'C' urned over toward the dam and disappeared beneath the torrent, and the eastern end of the section A'B' was broken up and engulfed. This left about 100 feet (B'D'), which was shifted slightly out of its parallel position. This section (B'D') was cracked from the crest as far down as could be seen. Sometime during Saturday night the smallest portion of this 100-foot section was swept away. The picture reproduced in Pl. XI, *A*, was taken from the top of the bulkhead at 2 p. m. on Saturday, April 7.

At 12.05 a. m., Sunday, April 8, the northern two-thirds (x y m n, ig. 10) of the west wall of the power house gave way and fell, taking with it the roof over the dynamo room and wrecking the correspond-ng part of the east wall. The power house was 198 feet by 54 feet, and had a total height on the river side of 112 feet. The walls were

of brick, except the first 20 feet, which were constructed of dressed granite rocks about 2½ feet by 5 feet by 3 feet. The dynamo floor (x y m n, fig. 10) was about on a level with the crest of the dam. The floor of this room extended as a gallery over the pump room (P) in which the big duplex pumps were located.

The broken sections moved back about 60 feet and the toe rested on the shore line of the tailrace. The impact and the resultant compressive stress on the stones on the curved face tore the granite facing loose from the core in several places. The section was stripped of its facing stones in the third course from the top as far down as could be seen, a distance of fully 30 feet. Some of the top granite stones of the section were loosened in their beds by the break and were carried away by the current.

Specimens of the cement of the core have been examined and these have been found to be first class in every particular. In some places breaks occurred through limestone rubble and the adhering cement, showing that the strength of the joint was superior to that of the limestone.

The behavior of the granite facing indicates very clearly that it was easily pulled off by the immense forces brought into play. The impact cracked the section along an irregular surface about 42 feet below the crest.

There was not sufficient continuity between the rubble core and the granite facing. There were slight irregularities in the line of contact between the granite and the rubble, but when subjected to the powerful forces of the water pressure the two separated at many places. In a few cases isolated granite blocks on the curved crest were forced from their beds, as shown by the dark spot on the curved crest in Pl. X, *B*.

The maximum depth of the water near the dam was only 38 feet below the crest. Thus at the time of the break the total depth was a little more than 49 feet. The lake had silted up from the original bed-rock bottom in the main stream exactly 30 feet. Had there been no silt a much larger volume of water would have passed and the results have been more disastrous at and below the dam. While this silt would flow, it was sluggish and served to retard the current, thus prolonging the flood several hours (it actually continued, with great velocity, for nearly two days). Within twenty-four hours the river level had fallen more than 40 feet, but this only served to confine the flood to the main channel, with little diminution of velocity. At 3.20 p. m., four hours after the dam broke, the water level had dropped 30 feet and was at the high-water mark of the old channel, cutting the banks both above and below the dam. Below the dam the alluvial banks reached a height of 64 feet above the toe of the dam. This whole mass was in a few hours cut back 40 feet. The effect of this continuous flood on the silt deposited in the lake since 1893 is considered under the heading "Silting up of Lake McDonald," *page 36*.

A. WESTERN PORTION OF DAM REMAINING AFTER BREAK.

B. PORTIONS OF BROKEN DAM BROUGHT DOWN BY FLOOD.

almost certain that the dam failed by sliding. It seems that ›int 300 to 400 feet from the east end the limestone upon which .m rested was of a friable nature. Mr. Frizell realized this, and stated to be a part of his plan, had he continued in charge of ›rk, to reenforce the bottom of the river just below the dam by ›nt foundation about 100 feet wide by 600 feet long; it was also .ry to his purpose to have the water of the tailrace run along › of the dam.

›rder to ascertain whether any of the foundation of the dam ›s in the broken gap, soundings were made in June and in the part of October, 1900. Three lines (A, B, and C) of soundings were parallel to the upper face of the dam, namely, at 2, 16.5, and 42 espectively, from the upper face. A cord was tagged every 20 nd the soundings were made with a sharpened three-fourths-›on rod. Stations were taken west to east. The following table the result of the soundings, the depth being measured from the ›f dam. When the October soundings were made the water sur-›as 56.1 feet below the crest of the dam. The rod soundings ›dded to this to give the depth recorded in the table.

›sult of soundings taken at Austin dam site in June and October, 1900.

tation.	Line A.		Line B.		Line C.	
	Depth in feet.	Bottom.	Depth in feet.	Bottom.	Depth in feet.	Bottom.
					Water's edge.	Dam.
					63.1	Solid rock.
					67.9	Do.
	Water's edge.	Dam	Water's edge.	Dam	68.4	Mud.
	73.5	Solid rock.	69.1	Solid rock.	69.5	Solid rock.
	69.5	do	69.1	do	70.1	Do.
	69.9	do	70.1	do	70.9	Do.
	70.6	do	71.1	do	71.3	Do.
	71.1	do	72.6	do	72.5	Do.
	72.3	do	72.6	do	72.4	Do.
	a 72.6	do	72.9	do	72.6	Do.
	a 72.3	do	73.1	do	73.5	Do.
	a 71.9	do	72.1	do	73.1	Do.
	a 71.3	do	71.1	do	71.3	Sand.
	a 70.9	do	69.1	do	71.0	Rock.
	a 68.1	do	68.9	do	69.6	Mud.
	Deep sand.		67.1	Mud	68.1	Gravel.
	do		63.6	Gravel	67.9	Mud.
	Water's edge.		63.1	do		Loose rock.
						Water's edge.

a Sand was found, but the sounding rod was driven through to solid rock.

If we remember that the height of the dam above the rocky bed of the river was 66 feet, and that the foundation was not (except as noted on the next page by Mr. E. W. Groves), even with its toe-hold, more than 68 feet below the crest, a glance at the foregoing table will convince anyone that no part of the foundation in the western 300 feet of the broken section remains. From the present ordinary eastern water's edge a large sand bank extends along the entire eastern section still remaining. Soundings were not made through this 30-foot sand bank, but the crest of the big section of the dam, shown in all of the views of the broken part, is only 4 feet lower than the crest of the portion standing, which indicates very clearly that its foundation went with it, as it is resting practically in the old tailrace, whose bed was lower than the bed of the dam.

On April 8, 1896 (four years before the dam failed), in a letter to the mayor, Mr. Frizell called attention to the fact that dangerous abrasion might occur near the point mentioned, i. e., 300 to 400 feet from the east end. The waters of the tailrace followed the toe of the dam fully 600 feet and were discharged through a narrow neck 45 feet wide, at an average depth of 2.8 feet during the day and about 3 feet at night when the full power was on. In March, 1899, the writer, with Mr. H. K. Seltzer, made soundings along the toe of the dam between this narrow neck and the power house. At or near the point where the break occurred the bottom was not reached with a rod 5.3 feet long, even when the hand holding it was thrust at least 2 feet below the surface. The water surface of the tailrace was then 2.5 feet below the toe of the dam. This makes the bottom of the tailrace more than 9.5 feet below the top of the toe of dam. The tailrace near the dam passed over a shoal-like formation and entered the tailrace pond about 50 feet from the east end of the dam. Between this point and the narrow neck alluded to the tailrace was bounded by the toe of the dam and an elliptical shore line. Its maximum width was 125 feet, its narrowest width (at the neck) 45 feet. It was at this neck that many measurements of flow were made during 1888 and 1889 for the United States Geological Survey. In March, 1899, simultaneous measurements were made of the tailrace at this neck and of the forebay; and while the flow through the tailrace exceeded that in the forebay, the difference was not greater than could be accounted for by the fluctuations of flow caused by increased demands on the street-car service. Early in 1899, when the lake level was 10 feet below the crest of the dam, the writer urged some of the authorities to shut off all power some night at 12 o'clock, and after the tailrace water had run off to have the flow measured in order to ascertain the leakage, if any; but there were difficulties which prevented the stopping of the works. It is probable that there was no leak under the dam from the lake. Water from the lake going under the dam would have been under a head of 66 feet, and would have emerged with a velocity of

A. BROKEN DAM SHOWING IN FOREGROUND SAND BAR LEFT IN MAIN CHANNEL.

B. REMNANTS OF DAM.

more than 64 feet per second, which would have cut away the limestone foundation in a few hours.

Mr. E. W. Groves, who was connected with the work, as an engineer, from the preliminary surveys to the completion of the dam, states that for the first 150 feet from the east bluff very good rock was found; that at that point a fault 75 feet wide was encountered, in which there was no semblance of stratified rock, most of the material being adobe or pulverized rock, with an occasional streak of red clay; that the excavation in this space was carried down 8 or 10 feet in the upstream trench, and the trench widened from 4 feet to 10 or 15 feet; that the fault extended to an indefinite depth; that from the west edge of the fault the foundation rock was poor for 350 feet, and that a supplementary protection was added to the upstream side opposite the fault by dumping clay along the face of the dam.

The limestone formation in the vicinity of the dam consisted of alternately hard and soft strata. The outcropping in Bee Creek (just above

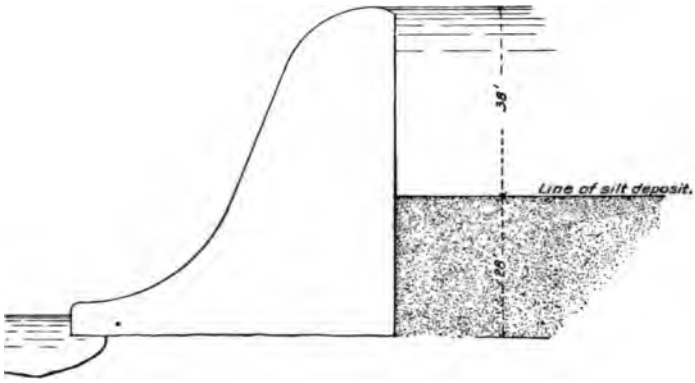


FIG. 11.—Cross section showing undermining of toe of dam.

the dam), that at Taylor's lime chute (about a half mile above the dam), and that through which the excavation was made to repair the head-gate masonry are all of that character. The soft strata could be handled without a pick and often with a shovel, but the hard strata was composed of a fairly good quality of limestone. In its western part the dam rested on one of these hard stratas. During a freshet in 1892 the overfall cut through this hard strata, tore up large pieces (some of them 10 feet long, 4 feet wide, and 2.5 feet thick and of 7 to 8 tons weight), and deposited a whole quarry in a confused and irregular pile about 150 to 200 yards farther down the river. These stones remained in that location until the big freshet of June 7, 1899, when they were carried away.

The foregoing facts are necessary for a proper understanding of what follows. In 1897, Mr. J. G. Palm, one of Austin's leading citizens and a cashier of the oldest national bank in the city, while fishing along the toe of the dam, ran his fishing pole under the toe for a

FIG. 12.—Geologic section east and west along Colorado River at Austin, Texas, showing Balcones zone of faulting. ta, Taylor formation; a, Austin chalk; ef, Eagle Ford shales; se, Buda (Shoal Creek) limestone; dr, Del Rio clays; fw, Fort Worth limestone; e, Edwards limestone; cp, Comanche Peak limestone and Walnut formation; gr, Glen Rose formation; t, Travis Peak formation.

distance of 6 feet. This shows conclusively that either the water flowing along the tailrace had scoured out the foundation under the toe of the dam or the overfalling water had undermined it. A large percentage of the water flowing over the east half of the dam at ordinary height reenforced the tailrace waters and produced a strong current along the toe of the dam for more than half its length. It has now been proved, by actual measurements, that the toe was cut under at some place, as shown in fig. 11. In speaking about the matter Mr. Palm said that he often wondered why the toe did not break off. This undermining of the toe left the dam exposed to the pressure of the water, and it became only a question of which was the stronger—the water or the friction between the dam and its bed.

In regard to the geologic formations, the following is quoted from a letter of Mr. Robert T. Hill, of the United States Geological Survey, in the Engineering News of May 3, 1900:

In the plateau country, which begins about a mile above the present site of the dam, the strata are firm and horizontal, and the river flows over ledges of firm and solid rock, which would have made a suitable and durable foundation for the construction. Just below this point, and within a belt of country upon which the dam is located, the strata are excessively jointed and faulted, constituting what is technically known as the Balcones fault zone, as shown in [fig. 12]. The geological formation is also different, consisting of the limestones of the Edwards formation, which are exceedingly porous and soluble, while to the west of the fault zone the strata are less soluble and more durable. The action of the subterranean waters upon the Edwards limestone results in dissolving it into caverns and crumbling strata, even where at the surface it appears perfectly solid and durable. Furthermore, artesian springs of great volume and pressure well up the joint planes and fissures in this formation. The site of the dam chosen crossed the river subparallel to one of the most conspicuous fault lines, at the northern (eastern) end of which, after the excavation and

construction had well advanced, a spring of the character mentioned developed, which greatly endangered the tie-on at the end and cost many thousands of dollars to circumvent. * * * Had the dam been located less than 2 miles above the present site, this structural condition would have been avoided.

A second geological consideration in the construction of the dam, and one to which sufficient attention was not, in my opinion, paid, was in the choice of material. Within 60 miles of Austin by rail are some of the most superb granite quarries in the world. This material was used to face the dam, but its center was built of the same soluble limestone as that previously mentioned, which was obtained from a quarry at the mouth of Bee Creek on the south (west) side of the river, less than half a mile from the dam. An examination of the face of the quarry shows the character of the material taken from it for use in the dam, and a glance is sufficient to show that its solubility was such as to render it utterly untrustworthy.

Mr. J. P. Frizell, after an examination of the preceding statements, adds that the location at Mormon Falls, 2 miles above the chosen site, presented points of decided superiority over the locality selected, but the board of public works thought that location inconsistent with the purposes of the improvement. Mr. Frizell does not consider that the solubility of the rock had any bearing on the failure, and sees no reason to doubt that the immediate cause was the undermining on the downstream side, caused by the abrasive action of the current and the constant stream of water coming from the power house and flowing along the toe of the dam on its way to the open channel of the river. A progressive weakening is attested by the fact that during the preceding year the dam had withstood a flood substantially as great as the one in which it failed. The toe of the dam, which was left without support by the undermining, contained granite blocks of more than 6 tons weight.

It is on record that the breaking down of this unsupported toe was imminent, in which event each of these stones would become a millstone (propelled in such a flood by some 2,000 horsepower) in the work of grinding the friable rock bottom and extending the undermining. At the wooden dam across Connecticut River at Holyoke, Massachusetts, an action of this kind became threatening in 1866. A pit 20 feet deep had formed on the downstream side of the dam. This danger was met by the construction of a massive apron of crib work filled with stone, which prolonged the duration of the structure more than thirty years, or until the construction of the present stone dam. At Austin the engineer had in contemplation from the beginning an analogous work, viz, an extension of the massive apron by a bed of concrete, to be applied as soon as the abrasive action had made sufficient progress to indicate the character and extent of the work required for its suppression.

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1895.

Sixteenth Annual Report of the United States Geological Survey, 1894–95, Part II. Papers of an economic character, 1895; octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894; octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Big Horn Range and Big Horn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar years 1893 and 1894, by F. H. Newell, 1895; octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography, 1896; octavo, 864 pp.

Contains papers on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett, and "Preliminary report on the artesian waters of a portion of the Dakotas," by N. H. Darton.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 536 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896–97, Part IV, Hydrography, 1897; octavo, 756 pp.

Contains a "Report of progress of stream measurements for the calendar year 1896," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "New developments in well boring and irrigation in South Dakota," by N. H. Darton, and "Reservoirs for irrigation," by J. D. Schuyler.

1899.

Nineteenth Annual Report of the United States Geological Survey, 1897–98, Part IV, Hydrography, 1899; octavo, 814 pp.

Contains a "Report of progress of stream measurements for the calendar year 1897," by F. H. Newell and others; "The rock waters of Ohio," by Edward Orton, and "A preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian," by N. H. Darton.

1900.

Twentieth Annual Report of the United States Geological Survey, 1898–99, Part IV, Hydrography, 1900; octavo, 669 pp.

Contains a "Report of progress of stream measurements for the calendar year 1898," by F. H. Newell, and "Hydrography of Nicaragua," by A. P. Davis.

WATER-SUPPLY AND IRRIGATION PAPERS, 1896–1900.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (fourth) page of this cover.

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